"NATURE". APRIL 4, 1959

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No. 4666 SATURDAY, APRIL 4, 1959 Vol. 183

CONTENTS

	Page
PRESERVATION OF THE COUNTRYSIDE IN BRITAIN	917
NEW ASPECTS OF THE GENETIC CONTROL OF INDUSTRIAL MELANISM IN THE LEPIDOPTERA. By Dr. H. B. D. Kettlewell	918
CÆSIUM-137 IN DRIED MILK. By D. V. Booker	921
RADIOACTIVITY OF SOILS, PLANT ASHES AND ANIMAL BONES. By Sir Ernest Marsden, C.M.G., C.B.E., F.R.S.	924
CONTAMINATION BY EXTRA-TERRESTRIAL EXPLORATION	925
OBITUARIES:	
SIR OWEN RICHARDSON, F.R.S. By E. W. Foster	928
DR. W. H. MILLS, F.R.S. By Dr. A. G. SHARPE	929
THE REV. H. H. SYMONDS. By Sir Herbert Griffin, C.B.E.	930
MR. AUGUSTINE COURTAULD. By Prof. L. R. Wager, F.R.S.	930
NEWS AND VIEWS	930
THE NATURE CONSERVANCY	935
THE NATIONAL PARKS COMMISSION	937
MAGNETIC FIELD OF THE EARTH. By Prof. T. G. Cowling, F.R.S.	937
RAILWAY ECONOMICS	938
POSSIBLE ENZYMIC MECHANISM FOR THE DEVELOPMENT OF RESISTANCE AGAINST FLUOROURACIL IN ASCITES TUMOURS. By Dr. Peter Reichard, Ola Sköld and Prof. George Klein	939
ELECTRON-MICROSCOPIC STUDY OF FINBACK WHALE MYOGLOBIN CRYSTALS. By D. E. Bradley	941
STRUCTURE OF SOME HYDROXIDES AND HYDROUS OXIDES. By O. Glemser; D. J. Kroon and C. v. d. Stolpe	943
ACTION OF AUXINS ON *Acetabularia* AND THE EFFECT OF ENUCLEATION. By Prof. Kenneth V. Thimann and Dr. Kurt Beth	946
REVIEW SUPPLEMENT:	
FROM DAN TO BEERSHEBA: EXCAVATIONS IN NORTH AND SOUTH PALESTINE. By Peter J. Parr	951
"ARMS AND THE MAN." By R. Brightman	952
MODERN MIND. By T. H. B. Hollins	953
NEUROPHYSIOLOGY OF BEHAVIOUR. By Dr. P. B. Bradley	954
PHYSIOLOGY OF THE CEREBELLUM. By C. G. Phillips	954
CLINICAL AND EXPERIMENTAL CANCER RESEARCH. By Dr. L. Foulds	955
MECHANISM OR VITALISM? By Dr. W. Grey Walter	955
BIOLOGICAL ULTRASTRUCTURE. By Dr. H. E. Huxley	956
CLASSIFICATION OF THE DIGENETIC TREMATODES. By Dr. Ben Dawes	957
HARMONIOUS HERPETOLOGY. By Miss A. G. C. Grandison	958
THE ART OF GRAFTING. By S. A. Pearce	958
UPPER DEVONIAN SPIRIFERS OF THE CATSKILL DELTA. By Dr. H. M. Muir-Wood	959
NAMES AND CIPHERS IN ORGANIC CHEMISTRY. By Dr. E. H. Rodd	960
NEW BIOCHEMISTRY. By Prof. F. G. Young, F.R.S.	961
FURTHER ADVANCES IN ENZYMOLOGY. By Dr. Edwin C. Webb	962
RADIOACTIVE ELEMENTS. By G. R. Hall	962
SATELLITE RESEARCH. By Dr. E. B. Armstrong	963
SHORT REVIEWS	964

(Continued overleaf)

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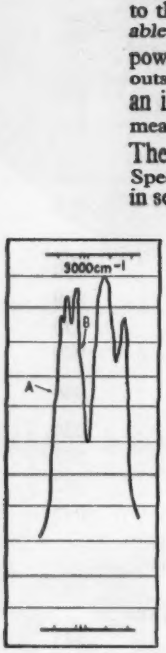

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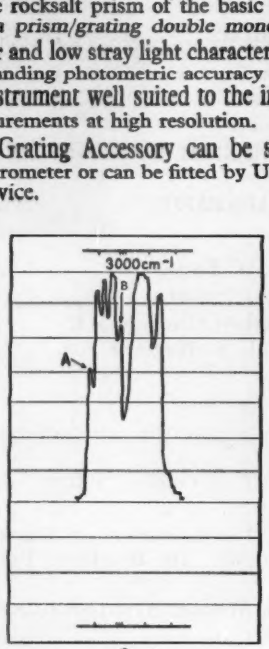

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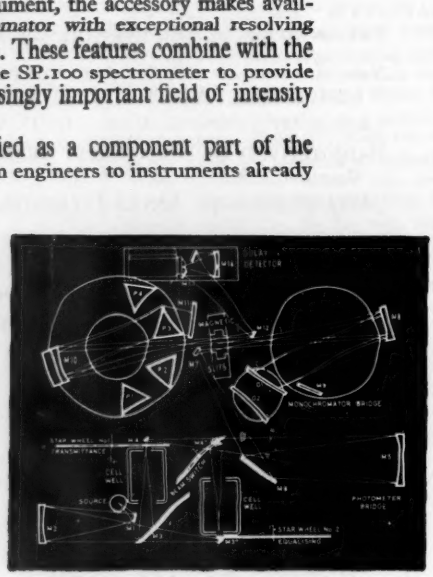

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LETTERS TO THE EDITORS

Page

BIOLOGY

Fluorescence Effects from Corals irradiated with Ultra-Violet Rays.—Dr. R. Catala-Stucki . 949

Lumpy Skin Disease of Cattle in Kenya.—M. L. Burdin and J. Prydie 949

Records of Young Eels in Kenya Rivers.—Dr. Vernon D. van Someren and Peter J. P. Whitehead 950

'Bat Erosion' at Niah Great Caves.—Tom Harrisson and Lord Medway 971

Galeal Structure in Adult Mosquitoes.—Gordon Surtees 971

Antimicrobial Substances from Resistant and Non-resistant Seeds.—Dr. Jasper C. Maruzzella and Dr. Martin Freundlich 972

Oxygen Deficiency and Radiation Damage in the Insect *Rhodnius*.—W. F. Baldwin and T. N. Salthouse 974

Effects of Kinetin, Gibberellic Acid and Certain Auxins on the Development of Shoot Buds on the Protonema of *Pohlia nutans*.—Dr. G. C. Mitra and Dr. A. Allsopp 974

CYTOLOGY

Some Effects of Colchicine on Lampbrush Chromosomes.—A. P. Amarose 975

Induction of Structural Chromosome Changes by Visible Light.—Dr. B. A. Kihlman . . . 976

ANIMAL PHYSIOLOGY

Hyperglobulinæmic Thrombo-Hæmorrhagic Diathesis.—Dr. Henry H. Henstell and Miriam Kligerman 978

Recurrent Inhibition in Cerebral Cortex.—Dr. Roger M. Morrell 979

Synthesis of Dextran Sulphate labelled with Carbon-14 and Tracer Experiments in the Rat.—Dr. H. Weigel and Dr. K. Walton . . 981

Passive Antibody Decay in Thyroidectomized Rabbits.—Dr. Ignatius L. Trapani, Dr. Allen Lein and Dr. Dan H. Campbell . . . 982

Balance Trials with Magnesium-28 in Sheep.—Alexander C. Field 983

Metabolism of Benzene Hexachloride by Resistant Houseflies *Musca domestica*.—Dr. F. R. Bradbury and H. Standen 983

Effect of Chloral Hydrate on Growth of Hair.—Prof. J. Randolph Murray 984

Crystals of Riboflavin making up the Tapetum Lucidum in the Eye of a Lemur.—Mrs. Antoinette Pirie 985

Gas Secretion in Coregonids.—Dr. G. Sundnes . 986

Page

A Critical Test of Antigenic Relationships.—Dr. J. G. Feinberg and Hazel Grayson . . . 987

PLANT PHYSIOLOGY

Copper–Cellulose Complexes.—Dr. D. S. Belford, C. D. Cook, E. H. Nevard and Prof. R. D. Preston, F.R.S. 988

Tetragonin : a Yeast Growth-regulating Substance from *Tetragonia expansa*.—Anna P. Schiffer and András Kovács 988

Separation of Anthocyanins from Plant Extracts.—Dr. B. V. Chandler and Dr. T. Swain . 989

Effect of Coumarin on the Germination and Growth of Rice Seedlings.—Dr. G. Misra and S. N. Patnaik 989

BIOCHEMISTRY

Reduction of Menadione in Hexane by Chlorophyll *a* under Ultra-violet Irradiation.—Rudolph J. Marcus and Lloyd K. Moss 990

Determination of Molecular Weights of Polysaccharides by Over-oxidation with Periodate.—F. W. Parrish and Dr. W. J. Whelan . . 991

Aerobic Fermentation of Whey by a Nitrogen-fixing Strain of *Aerobacter aerogenes*.—Prof. D. B. Johnstone and M. Pfeffer . . . 992

Amino-Acid Metabolism in Wool Roots.—G. E. Rogers and P. H. Springell 993

Role of Lysine in catalysing Ester Hydrolysis.—William R. Chesbro and Prof. Leslie R. Hedrick ; Alexander Gero 994

Synthesis of Adenylosuccinic Acid in Preparations of Mammalian Skeletal Muscle.—C. L. Davey . 995

Identification of 10-Hydroxy-Δ^2-decenoic Acid in Royal Jelly.—S. A. Barker, Dr. A. B. Foster, D. C. Lamb and N. Hodgson . . . 996

Effect of Reduced Diphosphopyridine Nucleotide on the Swelling of Isolated Mitochondria.—Dr. G. Di Sabato 997

Differences in Cyst(e)ine Content between Vegetative Cells and Spores of *Bacillus cereus* and *Bacillus megaterium*.—Vladimír Vinter . . 998

PHYSICAL SCIENCES

Thin Magnetic Films.—R. S. Webley . . . 999

Examination of Particulate Matter on Filter Membranes.—D. Anson, W. J. Grant and R. M. Jones 1000

Refractivity and Lattice Constant Ratios of Lithium-6- and Lithium-7-rich Fluorides.—Dr. R. W. H. Stevenson and P. T. Nettley . 1000

Spacing Anomaly in Electron Microscope Images of Crystal Lattices.—Dr. H. Hashimoto and Dr. H. Yotsumoto 1001

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PRESERVATION OF THE COUNTRYSIDE IN BRITAIN

THE two outstanding features of the year covered by the ninth annual report of the National Parks Commission* have been, in the Commission's own judgment, a series of Acts of Parliament with a direct bearing on its work, and Ministerial decisions on three extensive development proposals in national parks in Britain. Referring specifically to major industrial developments in the Pembrokeshire Coast National Park and the decision to sanction the construction of a nuclear generating station at Trawsfynydd in Snowdonia, the Commission affirms that, if it is to discharge the responsibilities which Parliament has entrusted to it, it must increasingly strive to ensure that every possible alternative site has been fully considered before permission is granted for such developments in a national park. It is reluctant to believe that, although it has been decreed in the over-riding national interest that particular major industrial undertakings shall be permitted in national parks, this signifies that national parks are being devalued as a national asset by those with whom the ultimate responsibility for these decisions rests.

Scant reassurance, however, on this point is to be found in the debate in the House of Commons on January 30 on the National Parks (Amendment) Bill introduced by Mr. A. Blenkinsop, though reference was freely made to the Commission's report in that debate; and it is in the light of that debate that the bearing on the Commission's work of the Acts in question—the Land Powers (Defence) Act, the Litter Act, the Local Government Act, the Milford Haven Conservancy Act and the Opencast Coal Act—is best appreciated. In so far as some of these likewise bear on the work of the Nature Conservancy†, a similar remark might apply to the ninth report of the Conservancy. Except against that background, the record of quiet but steady progress recorded in these two reports could engender an optimism that is quite unjustified and out of keeping with what remains to be done and the real national needs in regard to amenity and conservation.

Mr. Blenkinsop's Bill was opposed by the Minister of Housing and Local Government, Mr. H. Brooke, who pointed out quite rightly that the Bill was, in effect, a Financial Bill and that Parliament does not accept Private Members' Bills which propose the expenditure of public money. It is the tradition of the House that it should be the Government which shall choose and decide which proposals for additional expenditure should be placed before Parliament. Because of this principle, which is independent of the merits of the detailed provisions of the Bill from the point of view of the national parks, Mr. Brooke did not examine the Bill further. Most of its recommendations are, in fact, based on recommendations made to the Ministry by the Commission or by the County Councils Association; but in directing attention to this principle, Mr. Brooke placed the responsibility for the financial difficulties of the national parks in Britain fairly and squarely where it rests—with the Government.

There has never been any adequate financial provision made for the work of the National Parks Commission, either for its positive and constructive activities or even for its ordinary administration, largely because the burden of serving a national interest has been placed on the constituent counties, some of which are financially very weak. It is not, therefore, sufficient for Mr. Brooke to decline to undertake that the Government would introduce a Bill on the subject. If the idea of national parks is to have any real meaning, the Government must give serious consideration to their financial position and take early and adequate steps to meet their needs: a need which indeed is accentuated by the other grave threat to the whole conception—that of development. To concert the measures which keep the damage from development to a minimum usually demands much negotiation, consultation, and examination of sites, all of which costs money, and taxes to the limit the resources of the Commission and the other amenity societies.

Mr. Blenkinsop indicated clearly enough the minimum requirements. Less than £100,000 a year is being spent on the national parks of Britain, in the areas themselves or in the offices of the Commission. In the first place he proposed, in accordance with the Commission's own request, that the Minister's powers of providing grants should be widened to include any work done by the national park authorities under the broad enabling powers of the principal Act. This, in practice, would, for example, permit grants for such purposes as providing information centres in the parks, publicity action, anti-litter campaigns, etc. Secondly, he suggested the removal of those restrictions upon the powers of the Commission which prevent it from carrying out work which is the statutory responsibility of some authority but which (again often for financial reasons) is not being discharged. Thirdly, he strongly urged that, as recommended both by the Commission itself and the County Councils Association, the Minister should be allowed to make grants for the administrative expenses of the parks.

There were other minor suggestions in relation to the long-distance footpaths, the provision of wardens and making planning authorities responsible for the creation of new rights of way and their maintenance in national parks; but although the debate was poorly attended the Bill had support from all sides of the House of Commons, and it focuses attention

* National Parks and Access to the Countryside Act. Ninth Report of the National Parks Commission for the year ending September 30, 1958. Pp. iv+79+8 plates. (London: H.M. Stationery Office, 1958.) 5s. 6d. net.

† Report of the Nature Conservancy for the year ended 30th September, 1958. Pp. vi+119+14 plates. (London: H.M. Stationery Office, 1958.) 6s. 6d. net.

on the neglect of the Government, when the Act was originally passed and since, to provide the financial resources without which the purpose of the Act cannot be achieved. The Commission itself made further representations to the Minister during the year regarding the need for early amendment of the Act, but in his reply of April 11, 1958, Mr. Brooke held out no hope of Parliamentary time being available for a Bill on this subject. The Nature Conservancy is more restrained in its comments on financial needs, but the report makes it clear enough how far its scientific work and the management of the reserves are limited by lack of funds. The recommendation of the Select Committee on Estimates that "Ways and means should be sought for strengthening the Conservancy's liaison with the universities and for increasing the contribution to scientific research to be expected from them" is warmly welcomed.

The National Parks Commission in the present report also refers to the Land Powers (Defence) Act, 1958, concerning which the Commission was consulted, and in which provision was made that military manœuvres commissions should include, in addition to a member nominated by the Commission, "at least one person appearing to the Minister to be specially qualified to watch over the amenities of the areas in which the manœuvres are to be held". The Commission also welcomes the provision in the Act which empowers Service Ministers to use land occasionally for training and minor exercises, and thus enables them to reduce their holdings. The Litter Act, which received Royal Assent last July, is also regarded as a big step forward in the campaign against litter ; but it could well increase the financial needs of the Commission if the Act is to be made effective. The Local Government Act, 1958, leaves undisturbed the existing grants to local authorities under the National Parks and Access to the Countryside Act, 1949, but it is welcomed as a recognition of the national interest in national parks and in areas of outstanding natural beauty and as leaving the way open for extending these grants. While regretting, however, that further provision for opencast coal operations is made in the Opencast Coal Act, 1958, the Commission welcomes the improved safeguards for amenity contained in the Act.

These provisions follow corresponding sections in the Electricity Act, 1957, and the Milford Haven Conservancy Act, 1958, and these sections are heartening examples of the greater concern for the preservation of amenity which is now felt both in Parliament and in Britain generally. While it is true that the work consequent on the passing of the Town and Country Planning Act of 1947 and the National Parks and Access to the Countryside Act of 1949 has had a beneficial effect on the landscape, and that the cumulative effects of planning control have been considerable, the very passage of these new Acts and the granting of Ministerial consent for development proposals in national parks which have caused such disquiet to the Commission show the extent to which the effectiveness of its work lies largely outside its control. It depends on the amount of support which the Government is prepared to give for both amenity and conservation, at least in limited and specified areas, as an over-riding national interest, and to provide the financial and other resources to maintain that interest in the face of either departmental or sectional or local interest. That in turn ultimately depends on the development of an informed public opinion, alert to support the study work of planning authorities, within and outside national parks, and determined to safeguard with intelligent care the traditional and most vulnerable and often irreplaceable beauty of the countryside of Britain.

NEW ASPECTS OF THE GENETIC CONTROL OF INDUSTRIAL MELANISM IN THE LEPIDOPTERA

By Dr. H. B. D. KETTLEWELL
Nuffield Fellow in Genetical Research, University of Oxford

An absolute necessity to achieve dark coloration in order to preserve crypsis and survive has, in the past hundred years, confronted a large number of species of moths. County lists bear witness to the fact that some have failed and have been driven out of urban areas and their surroundings : the requisite mutations have not taken place in time. In at least two species (*Procus literosa* Haw. and the *Apamea characterea* Hb.), we have evidence that, after local extinction, an urban area has later been repopulated by melanic forms of the same species[1]. Until recently, we had assumed that successful industrial melanics had nearly always come about by the successful mutation of single dominant melanic genes, which, in one step, changed the insect from white to black[2].

In *Biston betularia* L., the peppered moth, I have shown by mark–release–recapture experiments that the cryptic advantage derived from this colour-change could alone account for the spread of industrial melanism[3]. Nevertheless, it has also been shown that, apart from colour, there are profound behavioural and physiological differences[4,5]. I have postulated theories based on the fact that melanic mutants, dominant in the few known instances and similar in every way to those spreading to-day throughout the industrial areas of the world, are to be found in moth populations, frequently as a balanced polymorphism, in many parts of the world remote from the effects of industrialization : the Caledonian forests of Scotland ; the sub-Arctic of Canada ; and the rain forests of South Island, New Zealand[6]. I have suggested that this same basic one-gene switch-mechanism has probably been used in the past for very different reasons when blackness conferred advantage[7] ; for

the assimilation of heat in cold climates; in dark rain forests; or possibly before deciduous trees succeeded the conifers in the northern hemisphere. In this instance, then, the 'pre-adapted' gene of Cuénot[8] is seen, not as a fortuitous happening, as has recently been suggested[9], but as a mechanism fulfilling recurring, though differing, needs which have from time to time been demanded for periods in the past history of a species. During these periods dominance has been achieved by natural selection.

Apart from this mechanism, we are finding evidence that others exist to promote darkness. One of these involves the use of polygenes, which bring about the gradual darkening of a normal population. There are certain species of Lepidoptera that have failed to mutate to a successful dominant melanic but have continued to survive in their typical form in urban areas. It has been repeatedly noted that, when these 'typicals' were compared with rural forms of the same species, the urban populations were much the darker. For example, *Gonodontis bidentata* Cl., which does not fly actively, has a single dominant black mutant, form *nigra* Prout. On Cannock Chase outside Birmingham, this comprises more than 50 per cent of the population. In central Birmingham, however, that mutant does not occur, but the typical specimens, which still survive there, are darker than their normal forms elsewhere. A large number of species in Sheffield, London and elsewhere fall into this category.

It is interesting to reflect on whether these darkening genes are the same as those which are responsible for blackening the heterozygotes of unifactorial melanics. We have previously recorded that the earliest heterozygotes of *B. betularia*, extracted from collections made in the past century, are different from the majority of specimens collected recently[10]. They were in fact somewhat intermediate in character, with varying degrees of white markings on the wings —a condition rarely found to-day. *B. betularia* form *carbonaria* now has complete dominance, the heterozygotes being indistinguishable from the homozygotes in the majority of individuals. Dominance has been achieved by the selection of modifiers in the gene-complex. Present indications are that in *B. betularia* many of these modifiers are not the same: the few remaining recessive typicals occurring in Birmingham are more variable, but not on an average darker, than rural ones. Probably the insect is so white, anyway, that it has not had the opportunity of mobilizing its polygenes for darkening, because the white form is always conspicuous in urban areas. Selective predation between typical individuals has, therefore, not taken place: they are eliminated indiscriminately. They continue to appear because of the advantage of the heterozygous *carbonaria* in the population.

Apart from the polygenic form, we encounter other modifications of the inheritance of melanism. In north Germany, *Lymantria monacha* L. has a gradation of phenotypes from white to black. The blackest (f. *atra* Linslow) is the result of three dominant genes (one sex-linked). Melanics of multifactorial origin are, surprisingly, uncommon in the Lepidoptera.

Sex-limited melanics, found in the female only, are known in a few species (*Phigalia pedaria* Fab.)[11], though whether the gene is in the *Y*-chromosome, or inherited cytoplasmically, has not at present been ascertained.

Until recently, I had repeatedly stated that no example was known of a *recessive* melanic mutation having spread: that recessive melanics were always rare, sub-viable and for the most part limited to non-cryptic species in which black forms, in past periods, had never been of use to the species[12]. This remains substantially true, but we have now found one: the bombycid moth, *Lasiocampa quercus* L., the oak eggar, and its two dark forms, which are increasing rapidly. One is green-black, *olivacea* Tutt (*olivaceo-fasciata* Cockerell), to which, until recently, all melanic *quercus* were referred. The other, *lurida* Cockayne[13], recognizably different when freshly hatched, is red-black. It seems likely that the two forms are modified expressions of the same recessive gene, or possibly they are alleles.

The oak eggar, in its northern form *callunae*, at times swarms on the heavily polluted Yorkshire moors. Unfortunately, it has a two-year life-history, the larva occurring in even years only and the moth in odd. In a sample of 493 moths collected in 1957, 23 (4·7 per cent) were of the dark recessive forms, so that about a third of the population were heterozygotes assuming equal viability of the genotypes. At present we cannot identify these with certainty, but there is evidence that a majority of the typical population are darker to-day than they were twenty years ago. Similarly, present-day melanics are darker than the earliest specimens taken from the same moor when they formed about 1 per cent of the population (though they do not fade).

A further interesting point in regard to form *callunae* is that, in Yorkshire, about 4 per cent of the wild larval population are black (82 in a random sample of 2,000 in 1956) though normally they are yellow-brown in colour (Fig. 1). They are hairy but are predated by cuckoos. A proportion (about 50 per cent) of the black larvæ produce black moths, as do a very much smaller proportion (less than 2 per cent, 1956) of yellow-brown larvæ. Natural selection, working on partial linkage between the genes controlling black larval and imaginal colouring, is the most probable explanation of the situation[14]. We are at present testing the cross-over values both in this locality and in other places where the same phenomenon occurs.

The female of the oak eggar, an insect of great size, is typically pale yellow. It hatches in the daylight hours and sits on heather stems, rarely flying except at night. The males, which are chocolate brown with bright yellow conspicuous bands, particularly on the underside, assemble in great numbers to them. The males, therefore, fly actively, in fact wildly, by day. To the human eye, form *olivacea* females were invisible on their backgrounds at, on an average, more than seventeen yards. The yellow female, on the other hand, was still visible at fifty-seven yards.

During the summer of 1957 we undertook an intensive study of this moth on Rombolds Moor, in June, where it was abundant. This is part of Ilkley Moor and is within fourteen miles of Bradford, Leeds and Skipton. The heather, walls and even the ground itself were black with pollution. Each day we observed large flocks of black-headed gulls (*Larus ridibundus* L.) flying slowly over the heather and dropping into it every few yards as they gorged themselves on the female eggars. The black-headed gull has only comparatively recently, in the past thirty years, extended its summer range to central England. Because of the insufficiency of melanic females, we were unable to undertake extensive mark-releases, comparable with those we had previously carried out on the peppered moth. On one occasion,

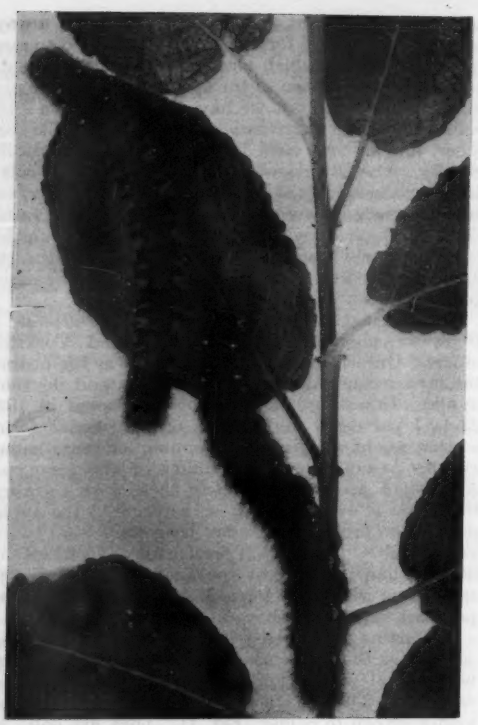

Fig. 1. Full-grown larvæ of *Lasiocampa quercus* L. Upper, normal yellow-brown colour; lower, melanic larva

however, of forty-six moths released, forty-four typical and two form *olivacea*, one *olivacea* was the only moth left after 2 hr. This suggests a very large visual selective advantage for the recessive dark mutant. Predation was so intense that few females could be seen at the end of a day, and the following year, in 1958, 134 larvæ only were found in a week compared with more than two thousand in a few hundred square yards during searching for 24 hr. in 1956 on precisely the same area.

Male eggars were also taken on the wing by the gulls and we observed swifts (*Apus apus*) catching them in numbers as well as wheatears (*Oenanthe oenanthe*). To us the melanic males were much more difficult to follow in flight than male f. *typica*. This was probably due to the absence of yellow bands, apart from their black colour (Fig. 2). We were also able to examine the 'feathering ground' of a pair of merlins (*Falco columbarius*) which were feeding extensively on the male moths. No melanic wings were present among the five dozen wings collected.

The dark mutants are to-day found throughout the industrial Yorkshire moors. Near Wallasey in Cheshire, form *olivacea* also occurs in about 5 per cent of the population, but here it has a one-year life-history[15]. In Caithness, northern Scotland, it constantly recurs in the population but is not so dark as elsewhere. In the rest of Britain it is a very rare mutant. Near Brandenburg in East Prussia, a similar or identical black mutant to f. *lurida* occurs near the estuary of the River Haval, and it is stated that it constitutes 100 per cent of the population, forming a local race[16]. 100 per cent of the caterpillars bred from this stock were also of the black form.

We have been able to collect further evidence on the spread of the recessive melanic in Britain. W. E. Collinson[17] has studied this insect in Yorkshire since 1936. He has observed the increasing frequency of the melanics which at that time formed about 1 per cent of the population. He has noted that the average colour of the typicals is getting steadily darker in this population, and he has observed the gradual darkening of the dark forms during the past twenty years. Moreover, he has recorded violent fluctuations in population size.

In 1957, I released 693 marked males and, using assembling traps placed over a square mile, recaptured 33 in a sample of 478 caught on subsequent days. This gives an approximate total male population of 10,000 for the peninsula of moorland on which I was working. There had taken place, therefore, a very high mortality-rate from the prodigious larval population of the previous year, 1956, when they swarmed in their thousands. A random sample of 311 cocoons picked up suggested the following pupal death-rate alone, regardless of late-larval mortality:

(1) Normal hatching		43
(2) Magpie predation. These have been observed to feed upon the pupæ in winter		81
(3) Disease. Virus and fungi. Unknown causes		170
(4) Parasites. Living solitary Ichneumonidae larvæ (1948)	4	= 17
Hatched Ichneumonidae	13	

This reflects a pupal mortality-rate of approximately 86 per cent. Of the total pupal population, therefore, 26 per cent were eliminated due to visual predation by magpies, and here it must be recorded that the *black* larvæ produce *black* cocoons, which are much more difficult to see than those of the typicals. Unfortunately, I was unable to recognize the differential predation on the cocoons because of bleaching.

We have then a situation in which two recessive melanic genes are spreading through a population. One controls larval colour, which is also reflected in the colour of the cocoon. The other is responsible for imaginal coloration. It seems that the genes for both are partially linked both in the Yorkshire and Cheshire localities. In Caithness, where *L.* f. *olivacea* forms a proportion of the population, the black larvæ do not occur[14]. The same situation is found in restricted areas in Holland and Denmark[18]. On

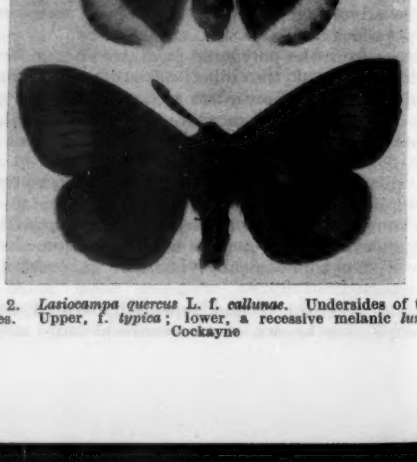

Fig. 2. *Lasiocampa quercus* L. f. *callunae*. Undersides of two males. Upper, f. *typica*; lower, a recessive melanic *lurida* Cockayne

the other hand, in Prussia there is evidence that a local population exists of black moths with black larvæ, though this is doubted by Cockayne[14].

We have worked on one other species in which larval and imaginal melanism is associated, the only other example known to me. *Arctia caja* L., the garden tiger moth, normally has crimson hind-wings which are only displayed on attack. There is a variable brown hind-winged form, *brunnescens* Stattermayer, which is the heterozygote of an all-black individual form, *fumosa* Hörhammer; it is therefore incompletely dominant. All *fumosa* so far have been bred from black larvæ. The heterozygous larvæ are indistinguishable from those of typical *caja*, and this character, therefore, suggests that the same gene is responsible for both larval and imaginal coloration.

It will be of the greatest interest to see whether in the Yorkshire black eggars, natural selection, working on the cross-over value, will eventually bring the two genes for larval and imaginal melanism so close together that they act effectively as a single supergene.

This would contrast with the situation in *Arctia caja*, where we feel confident that the association between black colour in larva and imago respectively has not been produced in this way. For here we are dealing with a very rare mutant, which has had no history of favourable selection necessary to bring two originally separate but advantageous genes together to form a controlling unit.

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CÆSIUM-137 IN DRIED MILK

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THE presence in human beings of traces of cæsium-137 derived from the world-wide fall-out of fission products from nuclear weapon tests was first reported by Miller and Marinelli[1] in 1956, and was also observed in human subjects in Britain by Rundo[2]. The main source of cæsium-137 in humans is probably cow's milk[3]. This article discusses the results of measurements of cæsium-137 and potassium in dried milk collected from different parts of the United Kingdom during 1957 and the first half of 1958. Measurements of the cæsium-137 and potassium contents of hay from four of these localities are also reported.

Samples of dried milk have been obtained from nine different areas in Great Britain, and studied for cæsium-137 and potassium content. Dried milk from one area has been studied since early in 1955, while most of the remaining samples were collected between April 1957 and June 1958. Table 1 gives the details of the factories, milk-collecting areas, the type of dried milk sample and the villages from which samples of hay were collected.

Estimation of Cæsium-137 and Potassium

Gamma-scintillation spectrometry was used for estimating potassium and cæsium-137 in dried milk with the aid of a sodium iodide crystal 3 in. diam. × 3 in. high with a photomultiplier and a five-channel pulse-amplitude analyser. Cæsium-137 was estimated from the 0·662-MeV. gamma-ray emitted by its short-lived daughter barium-137-*m*[4]; potassium-40 occurs naturally in potassium and emits a gamma-ray of 1·46 MeV.[4]. Counting rates in the two photopeaks from a 2-kgm. sample of dried milk were compared with those from a similar standard sample of dried milk containing additional standardized cæsium-137 and another sample containing added potassium. A few dried-milk samples of only 500 gm. weight were measured with less accuracy.

The activity in hay samples was measured with the co-operation of Dr. J. Rundo of the Health Physics Division, Atomic Energy Research Establishment, using a gamma-spectrometer designed for monitoring the human body. This instrument utilizes four sodium iodide crystals 4 in. in diam. × 2 in. high. Counting rates were observed on a 100-channel pulse-amplitude analyser, and were compared with those from a sack of hay containing added standard cæsium-137 sources, and a sack with potassium chloride added. The hay, which was harvested

Table 1. MILK- AND HAY-COLLECTING AREAS

Factory	Milk-collecting area	Type of sample	Hay sampling sites
Buckingham	North Buckinghamshire, South Northamptonshire	*F* and *S*	—
Carlisle	East Dumfriesshire, North Cumberland	*F* and *S*	Little Orton, Unthank, Dalston, Rockcliffe, Kirkbride
Carmarthen	Carmarthenshire	*F*	Llangain, Llanstephan, Conwil Elvet, Newchurch, Llanwinio
Coleraine	Counties Antrim, Fermanagh, Londonderry and Tyrone	*F*	—
Congleton	North Staffordshire, Cheshire	*F*	—
Driffield	East of North Riding, North of East Riding	*F*	Kilham, Wintringham, Nafferton, Scagglethorpe, West Heslerton
Frome	East Somersetshire, West Wiltshire	*S*	Leigh-on-Mendip, Holcombe, Binegar, Stratton-on-the-Fosse, East Horrington
Garstang	North Lancashire	*F* and *S*	—
Mauchline	South Ayrshire	*S*	—

F, dried full-cream milk; *S*, dried skimmed milk.

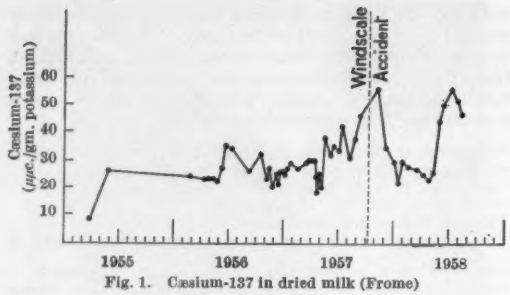

Fig. 1. Cæsium-137 in dried milk (Frome)

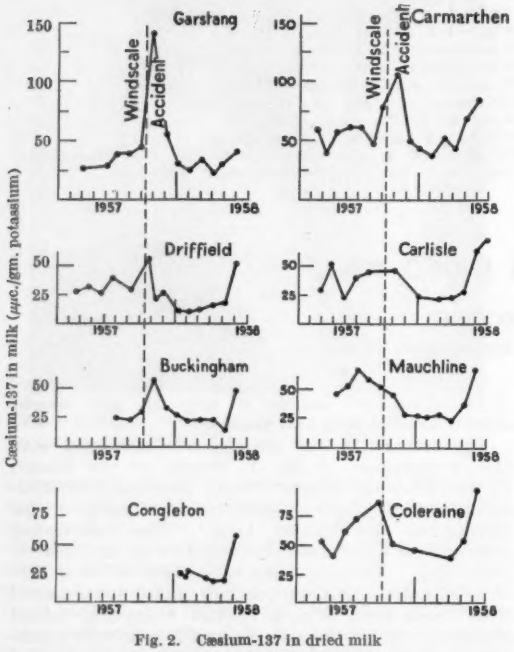

Fig. 2. Cæsium-137 in dried milk

in the summer of 1957, was measured in July 1958. This delay allowed the zirconium-95 which has a radioactive half-life of 65 days to decay by a factor of about fifty. At this time the gamma-rays of about 0·75 MeV. from zirconium-95 and its daughter niobium-95[4] did not mask the peak at 0·662 MeV.

Cæsium-137 and Potassium in Dried Milk

The cæsium-137/potassium ratio in dried skimmed milk manufactured in Frome, Somerset, has been plotted in Fig. 1 for the period 1955–August 1958; the results to January 1957 have already been published[5]. Fig. 2 gives the results for the cæsium-137/potassium ratio in dried milk from other areas. The measurements show that there is little, if any, variation in the potassium content of dried milk either with time or location. The average values obtained are 15·4 gm. potassium per kgm. dried skimmed milk, and 11·3 gm. potassium per kgm. dried full-cream milk. The probable error of counting on these measurements is ± 0·3 gm. of potassium per kgm. of dried milk. On the cæsium-137/potassium ratio the probable error of counting is ± 2 μμc./gm.

From Figs. 1 and 2 it is seen that there is an apparent seasonal variation in the cæsium-137/potassium ratio. The decrease in the winter may be due to the change in the feeding habits of cows during winter, when they are given supplementary food. Samples from all areas show an increase in the cæsium-137/potassium ratio in June 1958. The rise at this time of year is associated with cows going out to pasture in the spring; but the levels observed are enhanced by the higher than usual rate of fall-out at this time from nuclear test explosions[6]. In the only area from which samples have been measured beyond June 1958, it seems that the cæsium-137/potassium ratio reached a maximum in July 1958.

Average values of the cæsium-137/potassium ratios have been taken for each of the eight areas where results are available from April 1957 to April 1958. Samples collected in late October and November have been excluded (see next section). The average ratios have been plotted against the average annual rainfall in inches for each area in Fig. 3. There is an apparent correlation between the cæsium-137/potassium ratio in dried milk and the annual rainfall. The slope of the line in Fig. 3 gives a value for the ratio:

$$m = \frac{\text{Cs-137/K ratio in milk (μμc./gm.)}}{\text{annual rainfall in inches (in./year)}}$$

For the United Kingdom the value of m was 1·0 for the period April 1957–April 1958. A similar correlation between the cæsium-137/potassium ratio in milk and the annual rainfall has been observed by Anderson[3] in the United States, with values of m of 1·9 and 0·7 for two different parts of the United States.

Effect of the Windscale Accident

Inspection of Figs. 1 and 2 shows that dried milk from all collecting centres south of Windscale (Buckingham, Carmarthen, Driffield, Frome and Garstang) showed an increase in the cæsium-137/potassium ratio for the first sample manufactured after October 10, 1957, while the other samples (Carlisle, Coleraine and Mauchline) showed a decrease in the ratio. The largest increase, of 95 μμc./gm., was in the dried milk from Garstang (the significance of these measurements of the cæsium-137 content of dried milk can be judged from the recommendations regarding the permissible intake in emergencies made to the Medical

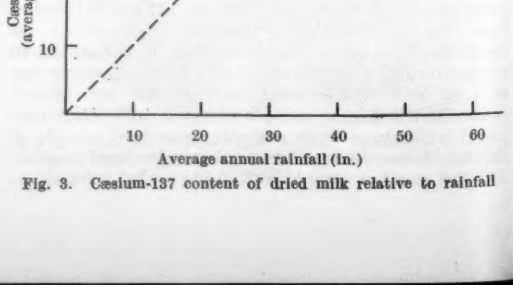

Fig. 3. Cæsium-137 content of dried milk relative to rainfall

Table 2. Cæsium-137, Potassium, Strontium-90 and Calcium Content of Hay (1957)

Location	Cs-137	K	Cs-137/K	Sr-90	Ca	Sr-90/Ca
	μμc./kgm.	gm./kgm.	μμc./gm.	μμc./kgm.	gm./kgm.	μμc./gm.
Carlisle	450	14·2	32	260	4·5	57
Carmarthen	870	8·8	99	530	5·3	100
Driffield	460	17·8	26	290	6·5	44
Frome	650	15·0	43	340	4·2	80
Probable errors of counting	± 70	± 1				

Table 3. Activity Ratios in Hay and Milk

Location	Cs-137 in hay	Cs-137 in milk	Observed Ratio	Sr-90 in hay	Sr-90 in milk	Observed Ratio
	μμc./gm. K	μμc./gm. K		μμc./gm. Ca	μμc./gm. Ca	
Carlisle	32	35	1·1	57	4·8	0·08
Carmarthen	99	61	0·6	100	7·5	0·08
Driffield	26	30	1·2	44	4·6	0·10
Frome	43	38	0·9	80	5·5	0·07
Average			0·95			0·08

Research Council by the Council's Committee on protection against ionizing radiations (*Brit. Med. J.*, in the press)), which is the station nearest Windscale, and is in the line of the plume of activity which was released in the accident[7,8]. Garstang is about 70 km. from Windscale.

Mayneord *et al.*[9] have studied milk from Cardiganshire during the period of the Windscale incident, and have shown that the cæsium-137/potassium ratio increased from 80 μμc./gm. to more than 300 μμc./gm. a day or two after the accident. By early November the ratio had decreased to about 150 μμc./gm., which is similar to the result of 107 μμc./gm. given in Fig. 2 for Carmarthen milk dried on November 5.

Using figures quoted by Booker[10] for the ratio of iodine-131 to cæsium-137 activities in herbage near Windscale, and the figures for the deposition of iodine-131 on herbage in North Lancashire, the deposition of cæsium-137 in the Garstang area can be estimated as 15 mμc./sq.m. of herbage. This corresponds to an increase of about 100 per cent on the previously existing cumulative cæsium-137 fall-out in this area from distant bomb tests[6,11]. (Gustafson *et al.*[12] have measured the cæsium-137 content of soil from Braidwood, Illinois, which was collected in October 1957. They find 14·3 mμc. of cæsium-137 per sq.m. of soil from an area which has approximately the same rainfall as Garstang.) However, the cæsium-137/potassium ratio in dried milk from Garstang in June 1958 was as low or lower than that in dried milk from other areas. These facts are consistent with the hypothesis that most of the cæsium-137 which appears in dried milk comes from direct fall-out on the herbage and little from the soil. A similar conclusion was tentatively reached by Anderson[3].

Cæsium-137 and Strontium-90 in Hay and Milk

Hay from the 1957 crop was collected from four areas corresponding to four of the areas from which dried milk was collected. In each area a sample of hay was collected from each of five farms (in villages named in Table 1) and the samples were mixed. Table 2 gives a list of results of the cæsium-137 and potassium analyses of the hay samples. Also included are the results of the strontium-90 and calcium analyses performed on the hay samples by Bryant (private communication). The cæsium-137/potassium and strontium-90/calcium ratios appear to be correlated with each other and are of the same order of magnitude.

In Table 3 the cæsium-137/potassium and strontium-90/calcium ratios in the hay samples are compared with the same ratios in dried milk averaged over the period June–September 1957. The results for the strontium-90 and calcium in milk are quoted from Bryant *et al.*[13]. The ratio of the results for milk and hay have been included under the heading "Observed Ratio" (Comar *et al.*[14]). In using this term the following assumptions have been made:

(1) The five farms from which the hay was taken were representative of all the farms sending milk to the collecting centres. (2) The grass cut for hay in the summer of 1957 was representative of the grass eaten by the cattle during June–September 1957 in respect of the cæsium-137/potassium and strontium-90/calcium ratios. (3) The cæsium-137/potassium and strontium-90/calcium ratios in the milk of the cows were representative of their feed at that time; that is, the milk was in equilibrium with the diet.

Of these assumptions (2) is probably the most doubtful, since the grass grown for hay would have a longer exposure to foliar uptake than that grazed continuously. During the summer of 1956, Bryant *et al.*[15] compared the strontium-90/calcium ratio in the accumulated growth of grass with that in which the grass had grown for only three weeks since the plot was last cut. This was done periodically during the summer at four stations. The accumulated growths had an average of only 28 per cent more strontium-90 per gm. of calcium than the new growth, which suggests that the error in taking accumulated growth would not be very large.

The assumptions are also supported by the fact that the Observed Ratios for the strontium-90/calcium ratios given in the last column of Table 3 lie not far outside the range of those reported from more carefully controlled experiments[14]. In particular, Morgan *et al.*[16] found an Observed Ratio of 0·09 for the strontium-90/calcium ratio in passage from diet to milk for a herd of cows at Sonning, Berkshire.

The Observed Ratio for the cæsium-137/potassium ratio varies considerably from region to region (from 0·6 to 1·2), but there is a clear indication that this ratio is near unity; this is very different from the Observed Ratio for the strontium-90/calcium ratio, which is about 0·1.

A qualitative comparison can be made with the cæsium-137/potassium ratios in human beings. Rundo (private communication) has found an average cæsium-137/potassium ratio of 45 μμc./gm. in individuals from Oxfordshire and Berkshire in the latter

half of 1957. This result is not significantly different from the ratios in hay and milk from Frome, which has a rainfall similar to that in Berkshire. A full study of the sources of cæsium-137 and potassium in human diet would be needed to obtain an Observed Ratio, but it appears that the discrimination factors are again much nearer unity than those observed with the strontium-90/calcium ratio.

Summary

Measurements of the cæsium-137/potassium ratio in dried milk and some corresponding results for hay have been obtained for the period 1957 and the first half of 1958. In dried milk from Driffield, which has a relatively low rainfall, the ratio in the summer of 1957 was 25–30 μμc. of cæsium-137 per gm. of potassium, and dropped to 10–15 μμc./gm. in the winter. Dried milk from Carmarthen, a high-rainfall area, showed ratios of 60–70 μμc./gm. and about 40 μμc./gm. in summer and winter respectively. The decrease in the ratio in the winter may be due to the change in feeding habits of cows, which are given supplementary food in winter. A large increase in the ratios in dried milk from all areas was observed in June 1958 and is associated with a larger than usual rate of fall-out in May 1958 and subsequent months. The average cæsium-137/potassium ratio in dried milk in μμc./gm. for the period April 1957–April 1958 is shown to be numerically equal to the average annual rainfall in inches in the area from which the milk was collected. The effect of the Windscale accident on the cæsium-137/potassium ratio in dried milk is shown to have been temporary. The cæsium-137/potassium ratio in human beings in late 1957 was about the same as that in dried milk from an area having a similar rainfall.

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RADIOACTIVITY OF SOILS, PLANT ASHES AND ANIMAL BONES

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ATTENTION has been directed by Turner, Radley and Mayneord[1] to the large variation in naturally occurring α-ray activities of foodstuffs and tissues. While at present there is little direct evidence as to biological significance, the subject is of sufficient interest to make it desirable to record some recent observations, at the Institute of Cancer Research, made possible by the kindness of Prof. W. V. Mayneord in making available to me apparatus developed for such measurements.

(1) The first observations concern the relative activities of bones of sheep, cows and of their offspring. It had been noticed from tests in New Zealand that the bones of calves and lambs were low in activity compared with those of adults, and, thanks to the co-operation of Dr. C. P. McMeekan of the Ruakura Animal Research Station, New Zealand, bones were made available by air-mail of a cow and a ewe and of their new-born offspring. The mother animals had been grazed on pasture grown on soil of α-activity 8×10^{-12} c./gm. The results are given in Table 1.

Table 1. Activity of Bone Ash (c. per gm.)

		Total α-activity	Approximate contribution of thorium products (per cent)
Mother cow	Femur shaft	$4{\cdot}8 \times 10^{-12}$	50
New-born calf	Femur shaft	$5{\cdot}8 \times 10^{-12}$	10
New-born calf	Femur head	$5{\cdot}2 \times 10^{-12}$	10
Mother ewe	Femur shaft	$4{\cdot}8 \times 10^{-12}$	40
Mother ewe	Femur head	$4{\cdot}0 \times 10^{-12}$	30
Lamb	Whole femur	$4{\cdot}8 \times 10^{-12}$	15
Lamb	Whole tibia	$4{\cdot}0 \times 10^{-12}$	14

These figures indicate an activity of the bones of the offspring only 10 per cent of that of the mothers and with relatively less thorium. The capsuled samples of bone ash from the mothers have shown an increase in activity of the order of 15 per cent in the three months following equilibrium with radon, etc. These increases are under long-period observation which will be reported later. Such measurements are of interest in comparison also with similar observations on many other bones of cows and sheep and of pastures, and apart from recovery of polonium there is the possibility that mesothorium is taken up relatively more readily than radiothorium. The average activity of a large number of such bones was about 5×10^{-12} c./gm. ash (max. $1{\cdot}4 \times 10^{-11}$), but in the case of three Suffolk sheep, killed and dissected in 1921 by Dr. J. Hammond, the average activity as now measured was only 7×10^{-12} c./gm. ash, with 10 per cent contribution from thorium products. This smaller activity may be due to decay of mesothorium and products (half-life 6·15 years) or may possibly be due in part to lesser use of superphosphate fertilizers at that time.

(2) The second set of observations relate to the possible influence of the superphosphate on plant and animal uptake of radioactivity. Samples of rock phosphates of various origins were collected and Table 2 gives the activity of the particular samples.

It has been suggested to me by an officer of the United Kingdom Geological Survey that the activity of fossil guano arises from fixation by the phosphate of uranium from sea spray through the ages, but the

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Table 2. TOTAL α-ACTIVITY (c./gm.)

Phosphate rock (Florida)	$2{\cdot}2 \times 10^{-10}$
Ocean Island	$2{\cdot}1 \times 10^{-10}$
Morocco	$2{\cdot}0 \times 10^{-10}$
Nauru	$1{\cdot}75 \times 10^{-10}$ (c. 10 per cent)
Makatea	$1{\cdot}4 \times 10^{-10}$
Christmas Island	$5{\cdot}5 \times 10^{-11}$
Gafsa (North Africa)	$5{\cdot}5 \times 10^{-11}$ (40 per cent)
Peruvian phosphate (old guano)	$4{\cdot}5 \times 10^{-12}$ (< 10 per cent)
Peruvian phosphate (recent guano)	8×10^{-13}

activity of Peruvian fossil guano does not fully confirm this. It is hoped to collect further samples which may provide information on this question.

It may be interesting to consider the effects on foodstuffs and animal bones of the growing use of superphosphates, a world increase of some 2½ times in the past 20 years and 10 times in the past 40 years. According to statistics from the Organization for European Economic Co-operation, approximately one million tons of superphosphate are used in the United Kingdom each year, and approximately 850,000 tons of basic slag and their content of uranium are added to the soils annually. In the United Kingdom at present, phosphate from Morocco is largely used, in New Zealand from Nauru—both active sources. This active material may be taken up by the roots into the plant or in the case of top-dressing of pastures it may, pending sufficient rainfall, remain on the leaves as dust to be consumed by grazing animals. Both these effects have been observed in the samples collected for test in the present experiments, but they were not laid out or planned with this particular type of test in view, and the quantitative aspect is influenced by varietal differences in uptake, for example, different strains of ryegrass. For plants grown in the same soil varietal differences are in general about as important as species differences, with Brazil nuts as an important exception. On average soils, plant ash shows results of the order $1{\cdot}6 \times 10^{-12}$ c./gm. Whole wheat and bran give results of this order also, but somewhat less and with significant varietal differences. Similarly, with the exception of such places as Devon, soils in general do not vary so much from place to place as one might expect from the activities of the parent rock material, and a general figure of 8×10^{-12} c./gm. may be used. The uptake by plants from soils is, however, governed more importantly by other factors.

Grass had been collected by the New Zealand Soil Bureau from six farms in Taranaki, New Zealand, all on andesite soil of activity approximately $3{\cdot}5 \times 10^{-12}$ c./gm. During the past ten years, two farms had been heavily top-dressed with superphosphate, two moderately and two received none. My measurements showed no very significant differences in activity of the grasses, especially when differing grass compositions are taken into account. More definite tests will be undertaken. In another case pasture was collected from a high-production test plot and the ash proved to have an activity of $1{\cdot}6 \times 10^{-11}$ c./gm. On further inquiry it was learned that the plot had been top-dressed a week or so before cutting and subsequent samples from the same plot, although at a different season, gave a value only one-tenth of this amount.

To enter into detailed description and discussion of all the results obtained would be beyond the scope of this article. Two important cases, however, are worthy of mention. The first is the soil covering of Niue Island in the Pacific. This is probably a volcanic ash shower material. Its α-activity is of the order of 7×10^{-10} c./gm., that is, some ninety times that of normal soils and with little contribution from the thorium family. By chemical analysis, kindly conducted at Woolwich, a figure of 60 p.p.m. uranium was obtained, but this would account for only about one-fifth of the activity. Qualitative α-pulse analyses conducted at Harwell indicate a major contribution of thorium-230 (ionium) and also, but less definitely, the possibility of an abnormally high uranium-235/uranium-238 ratio. If either or both of these results are corroborated, it would have very important geological significance. A study of activities of plants, bones of animals and humans of this Island will also be made shortly.

The other remarkable result is the large α-activity of slow-growing mountain pastures in Wales, Cumberland and Durham, particularly the first-mentioned. For these samples, along with many others and valuable co-operation and advice, I am indebted to Dr. Scott Russell, of the Agricultural Research Council Radiobiological Laboratory, Wantage.

At the end of the first month after ashing, the α-activity of one particular sample of Welsh grass ash was 8×10^{-11} c./gm., which rose 2½ months later to $1{\cdot}7 \times 10^{-10}$ c./gm. Except for the relatively small contribution of thoron as measured one might have attributed this to absorption from the soil of mesothorium and subsequent growth of radiothorium. It is hoped to secure α-pulse analysis scans of these remarkable plant ashes, also to study the uptake of uranium, radium and thorium by slow-growing plants on calcium-deficient soils and in different soil and climatic conditions. It should be noted that the last-mentioned figure of activity is greater than that of superphosphates although I am assured that no fertilizer was used.

I wish to express my appreciation to Prof. W. V. Mayneord and his staff for facilities placed at my disposal and for valuable discussion and suggestions.

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CONTAMINATION BY EXTRA-TERRESTRIAL EXPLORATION

AT the instigation of the International Council of Scientific Unions, an *ad hoc* committee was set up in April 1958 to investigate the problem of contamination by extra-terrestrial exploration. The committee consisted of: Prof. Marcel Florkin (convenor), Laboratoires de Biochimie, Université de Liège; Dr. J. Rösch, Observatoire du Pic-du-Midi, Bagnères de Bigorre, Hautes-Pyrénées (representing the International Astronomical Union); Prof. J. Bartels, Geophysikalisches Institut der Universität, Göttingen (representing the International Union of Geodesy and Geophysics); Dr. Donald J. Hughes, Brookhaven National Laboratory, N.Y. (representing the International Union of Pure and Applied Physics); Dr. P. Alexander, Chester Beatty Research Institute, Royal Cancer Hospital, Fulham Road, London (representing the International Union of Biological Sciences); Prof. W. O. Fenn, School

of Medicine, University of Rochester, N.Y. (representing the International Union of Physiological Sciences); and Prof. J. Roche, Collège de France, Paris (representing the International Union of Biochemistry). Prof. P. Swings, Institut d'Astrophysique, Université de Liège, and Prof. H. C. Van de Hulst, Sterrewacht, Leyden, were present as observers. To ensure wide regional representation the convenor asked for a chemist from the U.S.S.R. to act as representative for the International Union of Pure and Applied Chemistry. Unfortunately, it proved impossible for this to be arranged.

At the second meeting of the Committee, held at The Hague during March 9–10, the following summary recommendations were passed:

The Committee on Contamination by Extra-terrestrial Exploration was established in 1958 by the International Council of Scientific Unions to meet once to find out if the problem of contamination of extra-terrestrial objects by space vehicles represents a real problem. The report of this meeting, which was held in May 1958, was that in the Committee's view there is a real possibility that early experiments might spoil subsequent research. The Committee therefore proposed to the International Council of Scientific Unions that a code of conduct be drawn up for space research with particular reference to the allocation of priorities and sequences of different experiments. The Committee stressed that such a report would require active participation by experts, especially from the field of rocket technology. The International Council of Scientific Unions accepted this recommendation, and at its general meeting in Washington in October 1958 asked the Committee on Contamination by Extra-Terrestrial Exploration to hold a second meeting. At the same time the International Council requested the National Academies of the U.S.A. and the U.S.S.R. to assist the Committee with experts in rocket technology and with prepared documents. The Committee at its second meeting held at The Hague in March 1959 was able only to start its assigned task because the complexities of the problem made it impossible for the necessary detailed technical assistance to be available.

In the interval between the first and second meetings, a Committee on Space Research has been formed by the International Council of Scientific Unions to co-ordinate world-wide space research, and this new body enjoys the support of the American and Russian Academies. The Committee on Contamination by Extra-terrestrial Exploration feels that the detailed functions proposed for its second meeting form an integral and important part of the duties of the Committee on Space Research, and at this meeting the Committee confined itself to the general formulation of the problem and review of its initial report, which has been slightly modified.

General Principles

(1) Space research offers a challenge and opportunities which should appeal to the most imaginative minds. The greatest encouragement must be given to novel and unconventional approaches, and no proposal should be sanctioned which would hamper the experimenters' freedom of action unless there are compelling reasons. On the other hand, equally imaginative thinking is required when considering possible complications which can follow a particular type of experiment. Surprises are certain, and unlikely possibilities must be borne in mind when dealing with the problem of contamination, which is better defined as the problem of reducing the risk whereby one experiment may spoil the situation for other subsequent inquiries. The question of deciding whether such a conflict is likely to arise can best be dealt with by a committee or working group engaged in planning, or advising on, scientific experiments.

(2) Ideally, scientists should be asked to inform the Committee for Space Research as early as possible of each space experiment which is envisaged and of the methods to be used in its execution. The Committee on Space Research is broadly based and contains scientists from all disciplines; it is thus able to see much more clearly than the space research specialists possible conflicts introduced by such experiments and may be able to suggest ways of overcoming these difficulties.

(3) There are a number of obvious and necessary experiments which are bound to be done, and here the Committee on Space Research working group dealing with experiments may be able to suggest priorities. While it may not be possible to avoid all types of contamination, a proper sequence can ensure that the collection of data is not thereby hindered. For example, the Committee on Contamination by Extra-terrestrial Exploration recommends positively that no 'soft' landing, which requires the release of large quantities of gases, should be made on the Moon until experiments have been successfully carried out—or at least all reasonable attempts made—to determine the nature of the Moon's atmosphere.

(4) In view of the great uncertainties which face space research, all operations which are not capable of conveying meaningful scientific data are to be discouraged even if they do not appear to carry with them a known source of contamination. Risks with the unexpected must be taken, as otherwise no space exploration is possible; but such risks must be justified by the scientific content of the experiment.

Contamination endangering Physical and Chemical Studies

(1) *The Moon's Atmosphere.* The Moon's atmosphere contains only a small amount of matter (it is estimated at less than 100 tons) and is therefore extremely vulnerable to contamination. The release on the surface of any amount of volatile material (having a molecular weight greater than 60) within this range of magnitude, such as might be given off from explosions for marking purposes or to slow down the vehicle for 'soft' landings, is likely to remain on the Moon. Another factor which a change in the lunar atmosphere might bring about is an upset in the thermal equilibrium, and careful computation will be required before the magnitude of this effect can be assessed.

The release of any chemical marker on the surface of the Moon is therefore objectionable if it involves tons of material. If it has to be done, a flare releasing material quite unlike that normally present in the lunar atmosphere should be used, so that in subsequent investigations it can be clearly recognized as a contaminant introduced by man. Both in this connexion and because of increased ease in detection, a flare produced by sodium should be considered for this purpose. The sodium *D* lines could be detected at low intensities if a monochromator is used to cut out scattered light of other wave-lengths. Probably the quantity of material required to be visible through

a telescope, though not to the naked eye, would be insufficient to cause serious contamination of the atmosphere.

The possibility that a flare of this type might disturb the lunar atmosphere, due to the ionization of the sodium atoms by sunlight, has been considered, but such an effect is unlikely to persist for long periods.

From the foregoing it is clear that detailed exploration can very easily modify the lunar atmosphere, which should, if at all possible, be studied spectroscopically from either Earth or Moon satellites before landings are attempted. An accidental hit by a vehicle which has failed to go into orbit would probably not be serious, since the surface of the Moon must occasionally be subject to bombardment by heavy meteorites and the possible release of trapped gases by impact will not therefore cause a departure from natural conditions.

(2) *Moon dust.* The chemical composition of the dust is of the greatest interest to a wide range of sciences. Knowledge of changes of composition at different levels would also be informative, but may be difficult to interpret since bombardment by meteorites is likely to disturb the dust. For this reason mixing of some of the dust by rocket impact is unlikely to result in loss of information.

The suggestion has been made in the recent scientific literature that there are unstable structures of a high free-energy content (that is, containing a high concentration of free radicals) on the Moon, which may be caused to react explosively on coming into contact with organic substances from the Earth. The suggestion has therefore been made that great care be taken to exclude organic substances from space-vehicles likely to impact on the Moon. The Committee does not support the view that such a hazard exists, since such free radical structures would be triggered off by any impact which caused intimate mixing. Meteorites or solar corpuscular radiation would act as a fuse and initiate an explosive chain-reaction. The man-made object would do no more harm in this respect. The possibility that valuable information concerning cosmic dust may be lost by disturbing the surface of the Moon has been considered but is unlikely to be serious. Analysis of Moon dust can only provide a very incomplete picture of cosmic dust, because many of the constituents will be volatilized by solar radiation.

(5) *Radioactivity.* A serious danger of altering the Moon's dust will come from nuclear explosions. These will release fission products which under the conditions of extreme vacuum will enter the Moon's atmosphere and be rapidly distributed. These radioactive atoms will be in a highly reactive form and on coming into contact with Moon dust may form involatile compounds. In this way the whole surface of the Moon may acquire additional radioactivity which may interfere with subsequent radiochemical analyses that could be of the greatest value, in particular for problems relating to the history of the Moon. The explosion of a fusion device is likely to be more serious than that of a fission bomb, since the former will give rise mainly to volatile radioactive products, notably tritium, whereas the bulk of the volatile fission products are rare gases which will not combine with the Moon dust. However, the range of the small particles by which fission bomb activity is spread is likely to be very great on the Moon, and a serious danger of contamination would undoubtedly arise.

Although the relative extent of the contamination of the planets from a nuclear explosion would be very much smaller than in the case of the Moon, it may none the less be sufficient to interfere with detailed radiochemical analyses under certain conditions. Also the effect of introducing radioactivity on another planet where there may be entirely different levels of background radiation from those found on Earth could greatly influence any form of life found there. Although the objections against nuclear explosions on Mars and Venus may not be as compelling as in the case of the Moon, they are nevertheless well justified until more information is available.

Biological Contamination

Recommendation for immediate action. The sterilization of space-vehicles to prevent the spreading of spores and other terrestrial micro-organisms in the solar system is likely to present a number of technical problems that may not be easy to solve. The Committee on Contamination by Extra-terrestrial Exploration suggests that the Committee on Space Research initiates a study immediately of the methods by which the inside of space vehicles can be sterilized, bearing in mind the presence of delicate instruments that must not be damaged. As soon as possible, methods should be published by which this can be achieved, and it should be urged that all space probes be sterilized in this way. Although the Committee on Contamination by Extra-terrestrial Exploration feels that the possibility that life can persist on the Moon is sufficiently remote to justify being neglected, all Moon probes should be sterilized so that the difficult techniques of sterilization may be worked out in practice.

The outside of space-vehicles need not be sterilized, since exposure to the unfiltered solar radiation during flight will destroy all micro-organisms which have settled on the shell. The need for sterilization is only temporary. Mars and possibly Venus need to remain uncontaminated only until study by manned spaceships becomes possible.

(1) *Contamination of the Moon by living cells.* There is no reasonable possibility by which the introduction of cells such as spores or bacteria might give rise to life on the Moon of the same type (that is, containing deoxyribonucleic acid) as on Earth which might confuse later investigators. There are no cells on Earth which grow or multiply in the absence of water, and at the high vacuum of the Moon no water can exist on its surface.

(2) *Contamination of Mars and Venus.* There is a possibility of biological contamination of these planets, since there is a reasonable probability that the conditions on Mars are such that some terrestrial organisms might grow. Carbon compounds, light for photosynthesis and probably water and nitrogen are all available. It is therefore of the greatest importance that space-vehicles should not land either accidentally or deliberately on Mars (and possibly also Venus) unless all precautions have been taken to exclude living organisms from them. Otherwise the most challenging of all planetary studies, that of extra-terrestrial life, may be put in jeopardy. The same precautions in regard to the development of complex molecules which have been dealt with in respect of lunar contamination in paragraph 4 below apply equally to both Mars and Venus.

(3) *Panspermia hypothesis.* The suggestion that Moon dust might help in evaluating the hypothesis

that dissemination of life in the cosmos occurred by transport of forms of life in the cosmic dust must be rejected, because solar radiation (in a high vacuum) would decompose 'biospores' just as it decomposes cosmic dust. The possibilities by which a spore might travel through space inside meteorites involve so many improbabilities that they do not justify special consideration at this stage.

(4) *Development of complex molecules.* The basic problem concerning the origin of life is how complex molecules (on the Earth they are based on carbon) came to be built up and become replicated. It is conceivable that the interior of the Moon dust may provide some valuable clues in this direction. It is not beyond the bounds of possibility that some 'pre-life' processes may be occurring on the Moon, and these may be similar or different from those which have taken place on Earth. If there are such processes, then the introduction of 'foreign' macromolecules from the Earth may cause a serious upset in the lunar processes. Macromolecules from the Earth might under lunar conditions act as templates and provide new foci for 'pre-life' growth. If such events were started indiscriminately all over the Moon, the pattern might be distorted. It is important to emphasize that living cells are not envisaged for this process, and that in this connexion a dead bacterium from an aseptic rocket would be as harmful as a live one. The occurrence of any such growth reactions is remote and does not justify the imposition of any irksome restrictions on lunar exploration, but where reasonably possible it should be borne in mind. A simple precaution against endangering future studies might be to limit the areas of landings on the Moon and thereby to localize the effects—if any—of terrestrial templates.

OBITUARIES

Sir Owen Richardson, F.R.S.

In Sir Owen Richardson, whose death occurred on February 15, Britain lost one of her most eminent physicists.

Owen Willans Richardson was born in 1879 at Dewsbury in Yorkshire. He won scholarships, first to Batley Grammar School, thence to Trinity College, Cambridge. He was soon absorbed in research among the famous company inspired by J. J. Thomson. By the age of twenty-two, the results of his first investigations had been published, and for more than thirty years there followed a flow of papers—attacking fundamental problems of the times—at a rate which can seldom have been exceeded.

Early at the Cavendish Laboratory, Richardson carefully observed the temperature variation of the saturation electron current from a hot platinum filament (at low pressure). From considerations of kinetic theory, he quickly developed a clear explanation based on the evaporation of conduction electrons through a potential barrier at the metal surface. He obtained the formula $i = AT^{1/2}\ (\exp(-b/T))$, agreeing with his experiments and related formulæ, derived, apparently, about the same time by J. J. Thomson and H. A. Wilson from thermodynamical arguments. About 1903 he was elected a Fellow of Trinity College and became Clerk Maxwell Student. He was awarded the London D.Sc. in 1904.

Throughout the first fifteen or so years of Richardson's career, phenomena of thermionic emission, in the broadest sense, retained a central position in his interests; they were complicated by the inadequate vacuum and cleaning-up techniques of the times. Largely by his efforts and those of his friend, H. A. Wilson, the thermionic emission was finally formulated by $i = AT^2\ (\exp(-b/T))$, which is scarcely distinguishable experimentally from the original formula. Although the electron gas concept of the conduction electrons became modified, ultimately, by Fermi–Dirac statistics and wave mechanics, the second equation, Richardson's Law, remains. The early developments are described in his book, "The Emission of Electricity from Hot Bodies", first published in 1916. For his work in thermionics, a term he himself coined, he was awarded the Nobel Prize in Physics in 1928.

While still at Cambridge, Richardson's thermionic investigations led to studies of ionic recombination, of the diffusion of hydrogen through palladium and platinum and to the theory of the diffusion of dissociated gas in solution and to other projects. He had great mathematical facility.

In 1906 he was appointed to the chair of physics at Princeton University. Papers followed on the pressure shift of spectrum lines, the gyromagnetic effect, the ratio of the charge to the mass of positive ions, the energy distribution of electrons emitted by hot bodies, which, with F. C. Brown, he proved to be Maxwellian. Work followed on the reflexion of slow electrons by metal surfaces, gravitation and electron theory, theory of dispersion and residual rays, diffusion of neon through hot quartz and various projects on problems related to the work function, including the heating and cooling effects accompanying thermionic absorption and emission with H. L. Cooke, the theory of contact e.m.f., thermo-electricity and the photoelectric effect. With K. T. Compton he played a large part in the verification of the Einstein photoelectric law. He made many pioneer studies, some in collaboration with C. J. Davisson, C. Sheard and others, on the emission and properties of positive ions from heated metals and salts. He may have been the first to observe the emission of secondary electrons by positive ion impact. He also wrote on the asymmetric distribution of electrons produced by X-rays passing normally through a metal plate, etc.

In 1914 Richardson returned to England to become Wheatstone professor of physics at King's College, London. His book, "The Electron Theory of Matter", based on his Princeton lectures, was first published in the same year. It takes its place as a landmark in the history of physics. It is a model of the *ab initio*, not too contracted presentation, which university students like and deserve. Papers followed on absolute photoelectric yields with F. J. Rogers; metallic conduction, photochemical action and (1916–17) spectroscopic researches with C. B. Bazzoni. Limiting frequencies in the spectra of hydrogen and helium for 800-V. electrons were observed at 950–830 A. and 470–420 A. and compared with Bohr's calculations. Further theoretical work on the gyromagnetic ratio followed. In 1924 he was appointed Yarrow

research professor of the Royal Society, thereby being relieved of teaching duties. He began extensive investigations of the spectrum of molecular hydrogen with T. Tanaka, K. Das, P. M. Davidson, T. B. Rymer and others, and he himself made major contributions to the analysis of this most difficult of all molecular spectra. His book, "Molecular Hydrogen and its Spectrum", published in 1934, was based on his Silliman Memorial Lectures at Yale University. He retained interest in the H_2 triplet fine structures, on which he had unpublished high-resolution data, almost up to the time of his death. His last paper appeared in 1953; he had retired from the Yarrow professorship in 1944. Other work at King's College included an attempt, very early in the era of wave mechanics, to calculate the cold emission from metals under intense fields, and, in collaboration with H. T. Flint, interesting speculation concerning a least proper time.

Soft X-ray spectra of several metals were studied, especially with the late F. C. and Mrs. Chalklin. Extensive investigations of the emission of electrons during chemical reactions were undertaken, first with the late L. G. Grimmett and later with A. K. Denisoff. He acquired a splendid reflexion echelon for measurement of the wave-numbers and structure of the Lyman α line of H. He collaborated with W. E. Williams and J. Drinkwater in first measuring the wave-numbers and structures of the $H\alpha$ and $D\alpha$ lines to test the Dirac theory. Regrettably, a mysterious error crept into these observations. The results misled physicists until the Lamb–Retherford experiments. He made a notable study (1944) with the late Irena Gimpel of the reflexion of very slow electrons by copper, with apparatus earlier perfected by A. M. Crooker.

Richardson received honorary degrees of the University of Leeds (D.Sc.), St. Andrews and London (LL.D.); he was an honorary Fellow of King's College, London, and Trinity College, Cambridge. He was knighted in 1939. He was president of the Physical Society during 1926–28 and its honorary foreign secretary during 1928–45, which capacity included entertaining many distinguished foreign visitors.

There will be many who will recall his generous hospitality, and his first wife, the sister of H. A. Wilson, who was a most gracious hostess. He had a beautiful home with the finest English period furniture and a dazzling collection of paintings by Dutch and other old masters, fit for any national collection. About the house were several grandfather clocks, one in his library, by a contemporary of Thomas Tompion. They were wound once a week by the local clockmaker.

Sir Owen was a quiet and kindly man of few, well-chosen words, but he had a keen sense of humour. He was exceedingly proud of his northern origins and could speak the Yorkshire dialect. His forebears of Dewsbury were manufacturers, in the trade of the district. One of his stories (generally true, with a good moral) concerned two of these individuals, engaged in the development of a machine for processing cloth. After much time and effort and failure in getting the machine to work, one remarked despondently to the other, "It wearnt go". After some thought, the other replied firmly, "It mun go!" The work proceeded. In due course the machine was perfected. It was called the Mungo machine.

Richardson was versed in botany and nearly took up this subject at Cambridge instead of physics. He kept a fine garden. About the outbreak of the Second World War he bought a large farm, some miles from his home at Alton, Hampshire, and supervised this for several years. He bought it as an investment, as a war effort, and, he said, to try and get back the fortune lost there by some of his ancestors who had migrated south to that part.

His two sons and a daughter and his second wife survive him. His elder son is professor of physics at Bedford College, London. E. W. FOSTER

Dr. W. H. Mills, F.R.S.

THE sudden death of William Hobson Mills on February 22, at the age of eighty-five, deprived Cambridge chemistry of its last link with the nineteenth century. Mills went up to Jesus College from Uppingham in 1892, and took first classes in both parts of the Natural Sciences Tripos. After his election to a research fellowship in 1899, he went to Tübingen to work with von Pechmann, and there began his life-long friendship with N. V. Sidgwick. Upon his return to England he left Cambridge to become head of the Chemistry Department at the Northern Polytechnic in London, and during his ten years there he began the stereochemical work which was to gain for him an international reputation. He returned to Cambridge in 1912 as a Fellow of Jesus and demonstrator to the Jacksonian professor (then Sir James Dewar), and he remained there until his death.

Mills's achievements in the field of stereochemistry will always rank among the most powerful contributions made to the subject, for he had a flair for planning and carrying out a decisive experiment. By the synthesis and resolution into optically active forms of suitable compounds, he and his colleagues successfully demonstrated the non-linearity of carbon, nitrogen and oxygen in the oximes, the tetrahedral distribution of valencies in substituted ammonium ions and zinc complexes, and the planar configuration around 4-co-ordinated dipositive palladium and platinum. He played a great part in developing the steric theory to account for the optical activity of certain ortho-substituted diphenyls, and he later extended the idea of steric hindrance to free rotation to naphthalene, quinoline and benzene derivatives. Mills and Maitland, by their demonstration of optical activity in 1 : 3-diphenyl 1 : 3-di-α-naphthylallene, confirmed a prediction made fifty years earlier by van't Hoff and, as a writer in the "Annual Reports on the Progress of Chemistry" put it, "realized one of the ambitions of all stereochemists". Mills also made important discoveries in connexion with the chemistry of cyanine dyes and alkyl-substituted pyridines and quinolines.

Mills was elected to the Royal Society in 1923, and he received the Davy Medal in 1935; he was appointed to a personal readership in stereochemistry at Cambridge in 1931, and he was George Fisher Baker Lecturer at Cornell in 1937. Unfortunately, he could never be persuaded to publish the lectures and, indeed, throughout his life he seldom published anything but self-contained original papers. He was president of the Chemical Society during 1941–44. After his retirement, he seldom visited the laboratory, but he retained a wide interest in scientific matters, and his 1942 Pedler Lecture on "The Basis of Stereochemistry" anticipated much that has since been written on that subject.

No account of Mills's life would be complete without a reference to his extensive knowledge of the British flora and ornithology. He also had a long memory and a good knowledge of Cambridge history, and his excellence as a *raconteur* made him always entertaining company in the combination room of the College of which he was for nearly fifty years a Fellow, and during 1940–48 President. A. G. Sharpe

The Rev. H. H. Symonds

The Rev. H. H. Symonds died on December 28, after a long and painful illness; by his death, the Council for the Preservation of Rural England, the corresponding body in Wales and the rural preservation movement as a whole have sustained an irreparable loss. He was a firm believer in the value and possibilities of national parks for the good of the community, and made this province especially his own. He was largely responsible for the establishment in 1935 of the Standing Committee on National Parks of the Councils for the Preservation of Rural England and Wales under the chairmanship of Mr. Norman (now Lord) Birkett. This became his absorbing interest and together with the late John Dower he took on the work of honorary drafting secretary which he carried out until 1952, when he asked to be relieved of the duties so as to enable him to devote his time to other urgent work in connexion with the North Wales (Hydro-Electricity) Protection Committee, of which he was chairman. To his labours in the field of national parks to rouse and sustain public interest may justly be ascribed the introduction of the National Parks Act and the establishment of the National Parks Commission. It was a great disappointment to him that his tenure of office as a National Parks commissioner—an appointment long overdue when it at last came—was ended so quickly and abruptly by the illness which caused his death.

Symonds was no sentimentalist. He was a very able, hard-hitting protagonist, respected by his critics and opponents and admired by his friends and supporters. He was possessed of ability and intellect of the highest order; he had the gift of making the obscure transparent and the difficult plain. We must esteem him for his unswerving fidelity to his principles and his fearless propagation of his views. It would have been a great reproach to Britain if national parks did not exist as an enduring and appropriate memorial to one who was so entirely devoted to their service. Herbert Griffin

Mr. Augustine Courtauld

Mr. Augustine Courtauld, son of Samuel Courtauld, of Courtaulds, Ltd., died after a long illness on March 3. From his Cambridge days he had been interested in exploration and had travelled in Greenland with J. M. Wordie, of St. John's College, now Sir James Wordie, and in the Sahara with Francis Rodd, later Lord Rennell of Rodd. During 1930–31 he was in Greenland as a member of Watkins's British Arctic Air Route Expedition, and during the winter manned alone the meteorological station near the centre of the ice cap. The difficulties of travel on the ice cap in the autumn had made it impossible to stock the station with sufficient food and fuel for two men, and Courtauld, at his own request, stayed there alone—a feat of personal heroism and endurance, quietly undertaken, which equals any in polar exploration.

Courtauld was not a scientist; his interests were literary, but he equipped himself as a surveyor to make himself useful on expeditions. He shared the leadership of a successful expedition in 1935 to the Watkins Mountains of East Greenland. The party climbed the highest mountain in the Arctic, since named by the Danes, Gunnbjørns Fjæld, 3,700 m.

L. R. Wager

NEWS and VIEWS

Department of Scientific and Industrial Research Wolfe Award: Dr. L. Essen, O.B.E.

Dr. L. Essen was recently presented by Lord Hailsham, Lord President of the Council, with the Wolfe Award of the Department of Scientific and Industrial Research, in the form of a cheque for £500. This is the first of ten annual Awards to be made, under the terms of a will, to the scientist who has made an outstanding contribution to the research work of the Department during the previous twelve months.

Dr. Essen, a senior principal scientific officer at the National Physical Laboratory, received the Award for his work on the establishment of an atomic frequency standard as a basis for the future standard of time. Although the first attempts to employ molecular and atomic frequencies as 'clocks' were made in the United States, Dr. Essen was the first to appreciate the vital importance of this earlier work as a possible basis for a new physical standard of time. The cæsium frequency standard that he designed is used to calibrate the quartz clocks at the National Physical Laboratory and to monitor the *M.S.F.* standard frequency transmissions. Valuable information has been obtained on the performance of quartz clocks, the propagation of radio signals, the periodic and irregular variations of the rate of rotation of the Earth, and the value of the present international standard of time in terms of a particular frequency of the cæsium atom. The unit of time provided by the present atomic frequency standard can be determined in a few minutes to an accuracy of 2 parts in 10,000 million. This figure of merit is ten times better than that recently announced from measurements, extending over three years, of the astronomical unit based on the period of the Earth's revolution around the Sun. The National Physical Laboratory standard has, in effect, been the time standard of the world for the past three years.

Iron and Steel Institute: Medals and Prizes

The Council of the Iron and Steel Institute has awarded the following medals and prizes: *Bessemer Gold Medal for* 1959 to Prof. Bo Kalling, until recently director of research, Stora Kopparbergs Bergslags Aktiebolag, Sweden; *Sir Robert Hadfield Medal for* 1959 to Mr. Albert Jackson, technical adviser on steelmaking to the United Steel Companies, Ltd.; *Andrew Carnegie Silver Medal for* 1958 to Dr. P. Vasudevan, Department of Metallurgy, University of Manchester,

for a paper on "The Kinetics of Bainite Formation in a Plain Carbon Steel" (*J. Iron and Steel Inst.*, p. 386; December 1958); his co-authors, Dr. L. W. Graham and Dr. H. J. Axon, were not eligible for an award; *Williams Prize for* 1958 to Mr. H. C. Child, research manager, William Jessop and Sons, Ltd., for a paper on "Vacuum-melting of Steels" (*J. Iron and Steel Inst.*, p. 414; December 1958); his co-author, Mr. G. T. Harris, was not eligible for an award.

Honorary Member

Mr. Arnold Hugo Ingen-Housz, president of the Iron and Steel Institute during 1957–58, has been elected an honorary member of the Institute. Mr. Ingen-Housz, who was born at The Hague, received his technical education at the Technical University of Delft, obtaining a degree in mechanical engineering in 1911. After working with Royal Dutch Shell and the municipality of The Hague, he joined the Koninklijke Nederlandsche Hoogovens en Staalfabrieken N.V. in 1917 as technical assistant to the founder of the company, Mr. Wenckebach, in the planning and construction of the Ijmuiden plant. On the death of the founder in 1924, Mr. Ingen-Housz became joint managing director of the company, together with Mr. Kessler. When Mr. Kessler died in 1945, Mr. Ingen-Housz assumed the position of president of the management board, and held that position until his retirement this year. When he became president of the Iron and Steel Institute in 1957, Mr. Ingen-Housz was the first overseas member to receive this distinction since the late C. P. E. Schneider, who served during 1918–20.

Royal Aircraft Establishment: Mr. S. F. Follett, C.M.G.

Mr. S. F. Follett, who has been appointed deputy director (equipment) of the Royal Aircraft Establishment, graduated with first-class honours in engineering at the University of London. He served the Electrical Research Association on switchgear research during 1924–27, and joined the Electrical Engineering Department of the Royal Aircraft Establishment in 1927, where he was concerned with the application of electrical engineering to the aeronautical field, including electric power supply systems for aircraft, engine ignition work, early application of plastics, etc. He was appointed to Ministry of Supply headquarters as assistant director of instrument research and development (electrical) in 1946. In 1950 he was made director of instrument research and development, concerned with aircraft instruments, aerial photography and bomb-sights. He was made principal director of equipment, research and development in 1954 and, two years later, deputy director general. His former responsibilities were extended to cover armament and general mechanical accessory fields. He was appointed director general, Ministry of Supply Staff, British Joint Services Mission in Washington in 1956, and held this post until he took up his present appointment as deputy director of the Royal Aircraft Establishment.

Dr. A. G. Touch

Dr. A. G. Touch has been appointed senior superintendent of the Radio Department, Royal Aircraft Establishment, in succession to Dr. J. S. McPetrie (see *Nature*, **182**, 768; 1958). After graduating at Oxford, Dr. Touch served under Mr. (now Sir Robert) Watson-Watt at the Air Ministry Research Establishment, Bawdsey Manor, in 1936, where he was engaged on early work on airborne radar. In 1940, he continued the development of airborne radars at the Royal Aircraft Establishment, but left in 1941 to join the British Air Commission, Washington, until 1947. On his return in 1947 he became superintendent of the Blind Landing Experimental Unit. In 1952 he was appointed deputy director of electronics, research and development (air) at the Ministry of Supply headquarters and, in 1954, became the director responsible for the development programme for radio and radar equipment for the Naval Air Branch and the Royal Air Force. In 1956 he was appointed director of electronics research and development (ground), responsible for the development of ground radar for the Army and the Royal Air Force. At the end of 1956 Dr. Touch carried out an independent investigation into the crash of a 'Vulcan' aircraft at London Airport, at the request of the Minister of Transport and Civil Aviation. After a year (1957) at the Imperial Defence College, he returned to his previous post.

Mr. R. J. Lees

Mr. R. J. Lees has been appointed head of the Instrument and Photographic Department of the Royal Aircraft Establishment in succession to Mr. C. N. Jaques, who has taken up an appointment with the British Joint Services Mission in Washington. Mr. Lees was educated at King Edward's School, Stourbridge, and was a major scholar of St. John's College, Cambridge. He obtained first-class honours in Part I and Part II (physics) of the Natural Sciences Tripos. He also obtained a first-class external degree in physics at the University of London. Soon after the outbreak of the Second World War he joined the Air Ministry Research Establishment, Dundee, to work on radar and, apart from a period during 1955–56 when he was director of scientific research in electronics at the Ministry of Supply, London, he continued at this Establishment, now the Royal Radar Establishment, Malvern, until receiving his present appointment. For the past two years he has been head of the Airborne Radar Department of the Royal Radar Establishment.

The Nature Conservancy

In an attractive booklet in which the illustrations are liberal and sometimes coloured, the Nature Conservancy describes its growth and development since its birth ten years ago (see also pp. 917, 935 of this issue of *Nature*). Besides maps showing the location of the many nature reserves which have been established, the booklet describes the organization of the Conservancy and the way it operates under the ægis of the Privy Council. Of the staff of about two hundred employed, rather more than one-third are scientists engaged in research or conservation. The remainder include land agents, wardens and estate workers, cartographers and administrative staff. Regional officers were first appointed to different parts of England and Wales in 1953. Among the professions and skills represented by the staff are soil analysis, diagnosis of herbage eaten by voles, construction of sluices, deer stalking, mathematical design of scientific experiments, tree-planting, interpretation of aerial photographs, procedure for making by-laws, extraction of minute animals from the litter layer in woodlands, negotiations for land acquisition, control of peat erosion on high moorlands, stomach

analysis of seals, use of herbicides on vegetation between high- and low-water mark, mountain rescue, recording of vegetation changes on grassland, fixation of shifting sand dunes, and interception and arrest of deer poachers operating after midnight. The booklet (obtainable from the Nature Conservancy, 19 Belgrave Square, London, S.W.1, post paid 1*s.* 6*d.*) contains details of the public relations and educational work carried out by the Conservancy and is itself a model of how such publications should be produced.

Protection of the Shropshire Hills

The Minister of Housing and Local Government, Mr. Henry Brooke, has confirmed an order made by the National Parks Commission, establishing about 300 square miles in Shropshire as an area of outstanding natural beauty. The designated area includes the fine landscape around Church Stretton, with Caer Caradoc, the Long Mynd, the Stiperstones and the long ridge of Wenlock Edge, from which it extends north-east to take in the Wrekin and the Ercall. To the south-east, parts of the Clee Hills are included, and to the south-west the Clun Forest area on the Welsh border. Responsibility for preserving and enhancing the natural beauty of the landscape rests with the local planning authority, Salop County Council. Government grants can be made at the rate of 75 per cent toward the cost of treating derelict land, tree planting and preservation work. Grants are also available toward expenditure incurred in making agreements or orders for public access to open country and in appointing wardens. Designation does not of itself provide any additional right of access to private land.

Chinese Scientific Literature

The Lending Library Unit of the Department of Scientific and Industrial Research has started to collect Chinese scientific literature, and now receives regularly about 150 Chinese scientific and technical periodicals. The Lending Library Unit in London, which forms the nucleus of the new National Lending Library for Science and Technology, which will be set up at Thorp Arch, near Boston Spa, Yorks, in 1961, already has a large collection of Russian scientific literature, which is available to research, industrial and other organizations, through a loans service, and operates a scheme for the translation of Russian scientific literature, in collaboration with the U.S. National Science Foundation. This may possibly be extended in the future to include scientific literature from China.

Bulk Production of Silicon in Britain

Imperial Chemical Industries, Ltd., has brought into operation a large-scale development plant for the manufacture of high-quality silicon of semi-conductor grade. This remarkable material, which costs more than £100 per pound, has become of commercial importance during the past few years in the manufacture of semi-conductor devices, such as transistors, which are fast replacing conventional thermionic valves in many applications. The I.C.I. plant is operated by its General Chemicals Division on Merseyside. By the middle of this year capacity will approach 4,000 lb. per annum. Plans for much larger production are well advanced. Lump silicon, *p*-type, of resistivity greater than 200 ohm cm. is now available in quantity. Silicon in rod form, deposited direct from vapour and of exceptionally low boron content, is being produced in limited quantities in lengths of 24 in. and diameters up to 1 in. These rods are suitable for zone refining.

Smoking Habits

It often happens that investigators, particularly in the social sciences, must try to collect the information which they need by using questionnaires. One of the many problems that are apt to arise concerns the reliability of answers to questions which require an exercise of detailed and specific memory. Recently, the Tobacco Manufacturers Standing Committee issued a Research Paper (No. 2) entitled "The Reliability of Statements about Smoking Habits", by G. F. Todd and J. T. Laws (pp. 50; 1958). This should be consulted by anybody who has to try by questions to obtain factual information about habits or events covering any period in the past from a month or two to several years.

The authors show how statements about current smoking habits are generally reconstructed from a sort of 'mental picture' that the informant has of himself 'in his role as a smoker'. Changes in smoking habits are far more frequent than is generally thought to be the case, and so any information about them which refers to the past, based, as it must be, upon a general and personal assessment of current practices, is very likely to be in error. But the changes do not appear to be distributed in a random manner and, provided the sample groups investigated are large enough and the questions asked are answered seriously, so far as group tobacco consumption is concerned, information gained in this way is probably reasonably accurate in a statistical sense. For individuals, recall is frequently mistaken both as regards the amount and the kind of smoking carried on. Apart from the special topical interest of this study, it has wide methodological implications which ought to be considered by all users of questionnaires.

Bibliographies on Geology

Within recent years the United States Geological Survey has been very active in the publication of annotated bibliographies ranging over a wide spread of geological topics, many of them of world-wide interest. Among these works is a series of "Contributions to the Bibliography of Mineral Resources" (*Bulletin United States Geological Survey*, 1019*A-L*; 1954–58), which embrace separately published chapters reviewing the literature on the iron-ore resources of the world, on the world's quicksilver, titanium and nickel ores, and on the domestic distribution of magnesium salts, thorium and rare-earth deposits, salt beds, asbestos, and various industrial rocks. A second series of "Selected Bibliographies of Uranium Geology" (*Bulletin*, 1059 *A-E*; 1957–58) reviews the principal papers on uraniferous coal deposits, phosphorites, hydrocarbons, and uranium-bearing sandstones and igneous rocks in North America. Similar reviews of the international literature (including Russian works) on geophysics are published quarterly under the title "Geophysical Abstracts" (*Bulletin*, 1048, 1956; 1066, 1957; 1084, 1958); and another noteworthy compilation in the same category is "Bibliography of North American Geology", published yearly. A recently published bibliographical index to North American geology for the decade 1940–49 extends to 2,200 pages (*Bulletin*, 1049, 1957).

Apart from *Mineralogical Abstracts* (shortly to be published in a new format), British activity in geo-

logical bibliography has not of late been noteworthy, and for twenty years the only literature list covering Great Britain has been one compiled in the Library of the United States Geological Survey and published by the Geological Society of America. At the British Commonwealth Scientific Official Conference on Geology and Mineral Resources in 1948, it was resolved that each Geological Survey should produce an annual volume of abstracts covering its home ground. Most Commonwealth countries have now fulfilled this obligation, but there is not yet available any systematic compilation of abstracts covering the 300 or so papers on the geology of Britain published each year. In current international conversations on abstract journals in geology, it is to be hoped that this British domestic responsibility will not be overlooked.

Time Measurement

It will come as a surprise to many people who take their modern time services for granted to read that the first mechanical clock was made in the fourteenth century and that in earlier times the sundial and water-clock were the chief time-keepers. The Science Museum, South Kensington, has recently published the fourth edition of Part 1 of its Handbook of the Collection illustrating Time Measurement (pp. 60 + 12 plates. London: H.M. Stationery Office, 1958. 5*s*. 6*d*. net). Compiled by Dr. F. A. B. Ward, it traces the history of time measurement from its beginnings through the development of mechanical clocks and watches to chronometers. Chapters are devoted to electric clocks, including the Shortt free-pendulum and the synchronous motor clocks, to the quartz-crystal clock and to the atomic clock. Two chapters on chronographs and on various accessory mechanisms conclude the Handbook. Three hundred years ago, when the first pendulum clock was developed by Huygens, the maximum accuracy attainable was an error of ten seconds a day. To-day, the cæsium atomic clock has an error not exceeding one second in three hundred years, an improvement compared with Huygens's clock by a factor of one million. Indeed, the measurement of time is the most precise measurement of any physical quantity yet attained. This high accuracy is far beyond that required for civil purposes, and astronomers and geophysicists are likely to derive the most important benefits from the extreme accuracy now available. Those who are less interested in modern developments than in the history of science will welcome this descriptive Handbook for its account of the mechanical and electrical inventions which have contributed to the improvement of time-keeping.

Basic Biodynamics

In a recent publication, E. J. Kempf (*Ann. N.Y. Acad. Sci.*, **73** (4), 871; 1958) discusses current ideas on the interplay of genes and cytoplasm in relation to tissue and organ differentiation of multicellular organisms. After pointing out defects in existing explanations, he postulates six basic laws of biodynamics which he believes will "provide the biological sciences of genetics, cytology, embryology, biochemistry, physiology, psychology and sociology with a formulation of the basic natural processes involved in their special fields of investigation. These laws will clarify and facilitate the further development of secondary laws of the sciences of living behaviour". This somewhat extravagant claim is put forward in a singularly obscure and cumbersome style. Nevertheless, the paper contains a number of novel and stimulating ideas, and is worth close study.

Instruments in Industry

Evans Electroselenium, Ltd., Colchester Road, Halstead, Essex, has issued a series of twenty leaflets, each applicable to a particular industry, entitled "Instruments in Industry", which form a comprehensive guide to the various determinations that can most usefully be carried out using EEL photoelectric instruments. The fields of application include agriculture, ceramics, food, glass-making, medicine, photography and printing, plastics, sewage and water analysis, and textiles. The company has also produced a series of detailed method sheets for use with the EEL absorptiometer, the EEL flame photometer and the EEL colorimeter.

Textile Institute Scholarships

The Textile Institute is offering the following scholarships, for which applications should be made before April 30. The Textile Institute Cotton Industry War Memorial Trust Scholarship is intended to enable the holder to follow a whole-time course of study in textile technology at an advanced level (preferably, though not necessarily, a degree course) and/or obtain industrial training and experience of a special character at home or abroad for a period of three years. It has a maximum value of £300 for each of the first two years and £350 for the final year. The Peter Coats Scholarship is for two or three years to a value of not more than £100 per annum, for students at present studying in a public, grammar, or secondary technical school, or attending a part-time course at a technical college, who wish to take a course leading to a college diploma or other qualification in subjects connected with the cotton industry. The Rowland Spencer Scholarship, established in memory of the late Rowland Spencer of Helmshore, Haslingden, Lancashire, is open annually for training or research, to young persons of British nationality by birth who intend to enter and make their career in the textile industry and who are in their last year at a public, grammar, or secondary technical school or attending a technical college, or who have already qualified in textile technology, either as university graduates or as associate members of the Textile Institute. There is an annual grant of £100 during the period of this scholarship.

Canadian Society of Plant Physiologists

The Canadian Society of Plant Physiologists was founded at a meeting held in Saskatoon, Saskatchewan, on October 27, 1958. The new society grew out of a series of annual research conferences on plant physiology that had been held at various Canadian universities and research institutions during a period of eight years. The officers of the new Society are: *President*, Paul R. Gorham; *Vice-President*, E. R. Waygood; *Secretary-Treasurer*, D. Siminovitch; *Eastern Director*, R. O. Bibbey; *Western Director*, Stewart A. Brown. Correspondence can be addressed to the Secretary-Treasurer of the Society, Chemistry Division, Canada Department of Agriculture, Ottawa.

Biochemical Engineering

The various biological industries, including the large-scale production of citric acid, antibiotics, vitamins and other pharmaceuticals for both human and animal consumption have developed extremely

rapidly during the past decade. These, together with the expanding food-processing industries, require men trained in the somewhat rare combination of fields of engineering, microbiology and biochemistry. Man has for long controlled the activities of micro-organisms and enzymes on an empirical basis, either using them for fermentation processes or inactivating them to enhance the storage life of food. A much clearer understanding of the mechanisms involved is emerging, which is bound to be applied progressively to industrial and farming problems, and which, ultimately, will do much to overcome world-wide problems of ill-health and malnutrition. Biochemical engineering will necessarily play a major part in these developments, and it is important that British universities and technical colleges provide sufficient well-trained men and women in this field, able not only to improve existing methods but also to develop new ones as the need arises. There has already been some move to provide suitable training at the University of Birmingham and elsewhere, and University College, London, is now offering a one-year postgraduate course in biochemical engineering, starting in October. It is aimed at co-ordinating fundamental chemical engineering teaching with the requirements of the biological industries and will be balanced to suit previous experience of the student.

Photoelasticity at University College, London

Fifty years ago the late Profs. E. G. Coker and L. N. G. Filon began their collaboration in the development of the photoelastic method of stress analysis. To-day the method is recognized all over the world as one of the most valuable aids to efficient engineering design. The jubilee is to be celebrated at University College London, where most of the work was carried out, by a commemoration lecture and an exhibition of work in photoelasticity at the College. Sir Arnold Hall, president of the Royal Aeronautical Society, will preside at the commemoration lecture, to be delivered by Col. H. T. Jessop on April 15 at 6 p.m. The exhibition will be open on April 15, from 7 to 9 p.m., and on April 16 and 17, from 10 a.m. to 1 p.m., 2 to 5 p.m., and 6 to 9 p.m. The lecture and the exhibition will be open to the public free of charge and without ticket.

Announcements

Mr. J. McNicholas, general manager of the Manchester Rivers Department, and Dr. C. H. Mortimer, director of the Marine Station, Millport, and secretary of the Scottish Marine Biological Association, have been appointed members of the Water Pollution Research Board from April 1, in succession to Prof. J. E. Harris and Mr. A. Holroyd, whose terms of office have expired.

A one-day symposium on "Separation Processes in Analytical Chemistry" organized by the Royal Institute of Chemistry will be held in the Inorganic Chemistry Lecture Theatre, South Parks Road, Oxford, on April 24, at 10.30 a.m. There will be no charge for admission, which is not restricted to members of the Institute. Further details can be obtained from E. S. Lane, Chemistry Division, Atomic Energy Research Establishment, Harwell, Didcot, Berks.

The British Congress of Cosmetic Science, organized by the Society of Cosmetic Chemists of Great Britain, will be held in University College, Gower Street, London, W.C.1, during April 15–17. Sessions will be devoted to the analysis of raw materials; assessment of finished products; manufacturing or processing; and biological assessment. Further details can be obtained from the honorary organizer, Dr. R. H. Marriott, County Laboratories, Ltd., Honeypot Lane, Stanmore, Middlesex.

The second International Conference on Operational Research organized by the International Federation of Operational Research Societies (IFORS) will be held in Aix-en-Provence, France, during September 5–10, 1960. Suggestions for papers should be sent to the Secretary of IFORS, 11 Park Lane, London, W.1, before May 1, 1959, with a copy to the Secretary of the Operational Research Society of the country of origin. Manuscripts will be required by December 1, 1959, so that preprints can be made available before the Conference.

A symposium, intended for health physicists of atomic energy centres or installations, is being organized by the European Nuclear Energy Agency and the Danish Atomic Energy Commission, in co-operation with a number of scientists from Europe, from the United States and from Canada. It will be held at the Danish Atomic Energy Commission research centre at Risø, near Copenhagen, during May 25–28. The purpose of the symposium is to discuss scientific and technical aspects of health physics in atomic installations (radiation protection, control of radioactive contamination, emergency measures). Further information can be obtained from the European Nuclear Energy Agency, 38 Boulevard Suchet, Paris 16.

The twenty-fourth Cold Spring Harbor Symposium on Quantitative Biology will be held during June 3–10. The topic of the meetings will be "Genetics and 20th Century Mendelism"; and geneticists, anthropologists and palæontologists will participate. Individual sessions will deal with the theory of the gene and raw materials of evolution, natural selection and race formation, ecological systems and social organization, isolating mechanisms and speciation, the fossil record and rates of evolution, and trends of evolution. The Symposium is open to all who are interested, but because of limitations of space it is important to make advance reservations. Further information can be obtained from the Biological Laboratory, Cold Spring Harbor, New York.

The Tenth Congress of the International Astronautical Federation is to be held at Church House, Westminster, during August 31–September 5. Papers will not be restricted to a single theme, but will cover a wide range of astronautical topics, including: research applications of satellites and space-probes; existing and proposed projects for manned and unmanned space vehicles; conventional and unconventional methods of propulsion in space; problems in dynamics, control and navigation; re-entry problems; biological and medical aspects of manned spaceflight; legal problems. Papers for presentation should be submitted by June 1. Further details can be obtained from the Congress Secretariat, British Interplanetary Society, 12 Bessborough Gardens, London, S.W.1.

Nutritional Biochemicals Corp. of Cleveland, Ohio, has recently published its new catalogue listing more than 2,500 biochemicals for use in research and industry and now available through the Cleveland company. The catalogue can be obtained from the Nutritional Biochemicals Corp., 21010 Miles Avenue, Cleveland 28, Ohio.

THE NATURE CONSERVANCY

REPORT FOR 1957–58

THE ninth annual report of the Nature Conservancy for the year ended September 30, 1958*, follows the pattern of the previous report. There is a brief reference to the examination of the Conservancy's work conducted by the Select Committee on Estimates, and the Committee's recommendations in its seventh report for the session 1957–58 are being carefully studied. The declaration of fourteen new reserves during the year brought the total in Great Britain to seventy, with an area of 133,081 acres, and better progress was made in overtaking the arrears of estate management on existing reserves and, in the preparation of management plans. The principles of land use and management emerging from ecological research and conservation have begun to take shape and to secure wider recognition, as in the recent reports of the Royal Commission on Common Land and of the Committee of Inquiry into Inland Waterways, and in the Government's introduction of a Bill for the conservation and control of red deer in Scotland on the lines of the recommendations submitted by the Nature Conservancy and the main interested national organizations in Scotland.

Research grants to universities and outside bodies were again severely restricted by lack of funds, but the Conservancy welcomes the review of grant policy described in the last annual report of the Advisory Council on Scientific Policy and is examining its own functions in this respect. Three new grants became effective during the year and eight were extended or renewed. The creation of the new Council for Nature is warmly welcomed, and the Conservancy is already planning liaison with the Council in the fields of education and public relations.

The recommendations of the Royal Commission on Common Land regarding the avoidance of permanent enclosure and the preservation of common land as a national reserve to be available for multiple uses are closely in line with the Nature Conservancy's approach, but the Conservancy considers that the absence of detailed provisions for enabling commons in poorer areas to be brought under satisfactory management in the national interest, or in that of adjoining wealthier regions wishing to use common land for amenity or other purposes, is a serious weakness, and the report appears to pass somewhat lightly over the very real problems of relating the use of each area to its soil capability and to the use of adjoining areas of common land.

The Nature Conservancy considers that the findings and recommendations of the committee of inquiry into inland waterways deal adequately with matters raised in the Conservancy's evidence to the committee. No evidence was submitted by the Conservancy on the future of the Norfolk Broads, and while the committee was not impressed by the proposal to make the Broads a national park, it thought that an expenditure of £30,000–£60,000 a year in place of the present £19,000 would be sufficient if the Great Yarmouth Port and Haven Commissioners were reconstituted (possibly including nominees of the National Parks Commission and the Nature Conservancy). The Conservancy agrees that these proposals would not run contrary to the interests of the naturalist and scientist, as some broads are unlikely to be restored to navigation and can be retained primarily as nature reserves. Moreover, the Conservancy urges that it is imperative to stay the deterioration of the broads and that this would not prejudice further action in the light of long-term research. The Conservancy considers there is no reason why agreement should not be reached on these lines.

Apart from recording progress in national nature reserves, the section of the report dealing with conservation is of particular interest for the details given of the management plans for three reserves: Woodwalton Fen (Huntingdonshire), Roudsea Wood (Lancashire) and Newborough Warren–Ynys Llanddwyn (Anglesey). For the first the objectives are: to conserve the characteristic plant and animal communities, including rare species of special interest which exist on the Fen; to encourage and carry out research and survey work on the fauna and flora of the Fen, and any other subject which may increase our knowledge of fen natural history and the factors which influence it; and to permit access to the reserve by interested members of the public, provided a permit is held, and to allow reasonable collecting, as well as to maintain good relations with neighbours with respect to boundary dykes, water levels in external systems and control of pests. For Roudsea Wood, the plan aims to establish a sample of native woodland characteristics of north-west England; to encourage the fauna and flora associated with this; and to provide facilities for study and research. The principal objectives at Newborough Warren are to carry out detailed surveys and to compile records of the entire range of scientific interests; to conserve examples of distinctive dune and slack flora and fauna; to increase the diversity of wild life within the reserve by extending some habitats and creating new ones; to enrich the ornithological interest, by influencing the balance of populations to preserve adequate numbers of species of birds and mammals most characteristic of the habitat; to control public access by a permit system, but to allow as much freedom as is compatible with conservation and research; and to develop the educational potentialities of the reserve.

Both the sections of the report dealing with conservation and that dealing with scientific research describe in some detail the rapid progress made in providing man-power, accommodation and other resources to make a firm base for research and con-

* Report of the Nature Conservancy for the year ended 30th September, 1958. Pp. vi+119+14 plates. (London: H.M. Stationery Office, 1958.) 6s. 6d. net.

servation on the Isle of Rhum. It has been shown conclusively that it is impracticable to produce commercial timber on Rhum, and the immediate and medium term productive potential of Rhum is being assessed, particularly as regards livestock and red deer. The Macaulay Institute of Soil Research is making a comprehensive soil survey, and a preliminary report has already resulted on the soils and geology of Rhum. A programme of vegetation recording has presented a picture of widespread erosion of the soil and deterioration in the quality of the cover.

In this report the section describing the scientific advisory services of the Conservancy is specially interesting. At Milford Haven the developers submitted new alternative proposals involving the exploitation of old gravel workings high up the shore, which will not be inimical to the scientific interest of the area, after it had been pointed out that the original plan to extract sand and gravel from Dale Bay and the adjacent Gann Flats would destroy the existing delicate balance of environment and living organisms within the Crabhall Saltings and the Dale Bay shore. The outcome of this case thus illustrates how early and full discussion between developers, planning authorities and the Conservancy can avoid developments which would be inimical to wild life. A detailed biological survey of the estuary is being undertaken by Prof. E. W. Knight-Jones with a grant from the Development Commission. Increased urgency was expressed over the conservation and use of water and the need of ancillary research, particularly in opposing the Tees Valley Water Board's proposal to build a reservoir in Upper Teesdale, and special attention has been directed to accurate methods of measuring rainfall, loss of water from evaporation and run-off.

Further representations were made in connexion with the use of chemical sprays to control vegetation on roadside verges, but it has not yet been possible to set up the panel on risks to wild life. The Conservancy has not so far received any substantial evidence that toxic chemicals used in agriculture are causing any important or widespread reduction in bird or mammal populations. The red deer survey undertaken by Dr. Fraser Darling has now provided detailed information on about one-third of the ground in Scotland on which red deer are established, and sufficient material to prepare, negotiate and adopt a soundly based national scheme for red deer conservation and control in Scotland acceptable to all the main interests concerned. The Conservancy has been enabled to develop a red deer research programme and provided with the experience and resources to undertake further development of investigation and advising services in this field. The present red deer population of Scotland is estimated at about 120,000, and it is hoped that the Deer (Scotland) Bill, which received its second reading in the House of Commons on February 3, will put a stop to the cruelty from poaching by gangs, which is the most urgent aspect of the problem. The red grouse investigation continued, as well as research on seals on the Farne Islands. The Development Commission was considering the possibility of a grant to continue and expand the research on grey seals by appointing a zoologist to investigate the fishery and marine biological aspects.

Among the research programmes which have already yielded definite results is the vegetation survey of the Scottish Highlands which had led to improved understanding of the reasons for the striking patterns of contrasting heather and grass moorlands and bracken and scrub-covered slopes which are so conspicuous in the Highlands. The Conservancy proposes to apply this knowledge within its own mountain reserves and to attempt to unravel some of the problems the Survey has indicated with the view of demonstrating a sound system of hill management. The geological survey of the Moor House Nature Reserve has been in progress for four years and work continued on the experimental introduction of Arctic–Alpine and montane species of plants into selected areas fenced off to exclude sheep. A study of the productivity of alluvial grasslands was initiated as well as longer-term experiments to estimate the annual production of plant material by peat under different regimes of extraction cropping. Other experiments at Moor House relate to the reclamation of eroded peat areas, the establishment of high-level woodland, the relation between seasonal growth in height of Scots pine, rowan and birch, and air temperature and soil temperature at rooting depth. In a further study of the craneflies (Tipulidae) particular attention is being paid to the short-palped craneflies which are restricted to peat moor.

In Snowdonia investigations on the soils, vegetation and land use continued, and the recording of chalkland grassland transects in south-east England has afforded evidence of continued increase in the proportion of the more palatable grasses and the legumes in places where the numbers of rabbits had been much reduced.

Seven important papers have now been published on the development of woodland conditions under different trees and major sections of this research are now complete. In the present report, work on the influence of site factors on sessile oak (*Quercus petraea*), Scots pine (*Pinus sylvestris*) and silver birch (*Betula verrucosa*) is described, as well as continued studies on the oak and ashwoods of northern England, and on the defoliation of oaks by the oak-leaf roller moth (*Tortrix viridana*). Besides detailed studies of the ecology of earthworms at the Moor House Nature Reserve, the study of earthworms in woodland soils is an expanding part of the work of the Merlewood Research Station. Studies of the ant populations of east Dorset heathland and on dragonflies continued, as well as the study of the population cycle and food of the short-tailed vole (*Microtus agrestis*), and the investigation on the pine martin on Benin Eighe. In coastal research the survey of brackish marsh communities of *Spartina townsendii* in Poole Harbour was extended from Arne Bay to the north shore of the harbour at Keyworth and Lytchett Bay. Studies are being made of the rate of accretion of mud on *Spartina* marsh in Bridgwater Bay and of the control of *Spartina* by herbicides. A further study has confirmed that Brent geese make use of a much wider range of salt-marsh foods at Scolt Head Island than has been generally supposed. Experimental work into the movement of beach material at Bridgwater Bay has yielded interesting results on the development of shingle complexes and on the interaction of shingle and grass. The large-scale mapping of the physiographical forms of the coast eastwards of Hinkley Point has been completed. At Braunton Burrows extensive planting of marram grass (*Ammophila arenaria*) has effectively stabilized much of the dune area over which military movements had destroyed the protective cover of vegetation.

THE NATIONAL PARKS COMMISSION

REPORT FOR 1957–58

THE ninth annual report* of the National Parks Commission covers the year ended September 30, 1958, and records the establishment of three further areas of outstanding natural beauty, the Minister having confirmed the Commission's orders designating the Northumberland coast, the Surrey hills and Cannock Chase. Decisions are awaited on the Dorset coast and hinterland and the Shropshire hills, and the Commission expects during the next few months to be submitting for confirmation orders for the Cornwall areas, sections of the north and south Devon coasts, the Malvern Hills and the Sussex Downs. As regards the 'Long Distance Routes', the Commission has completed its report on the South Devon Path and its work on the North Devon Path is well advanced. Solutions are being sought for a new line in the Pennine Way, the Blakehope Fell area of Northumberland, and this will leave Edale Bridge as the only major problem of the route outstanding. The Commission again comments on the good work being done by voluntary assistance in clearing disfigurements from disused gun-sites and other sites of wartime activities in the Pembrokeshire Coast National Park, the Lake District, the Peak District and elsewhere, but rightly points out that it is a national disgrace that so many disfiguring marks should still remain. It welcomes the assurance given in the House of Commons on July 2 by the Parliamentary Secretary to the Ministry of Housing and Local Government that purchasers of an airfield are now required to leave it reasonably tidy.

As regards the National Parks themselves, the Commission's report stresses the creative work being undertaken in the Peak District, where the Board's current programme includes many plans for the removal and concealment of scars and blemishes on the landscape; public access is being extended, as well as information work and the development of the voluntary warden service. In the Lake District, caravan sites have received much attention and anti-litter work has increased, while in Snowdonia an economic survey of the Park is proposed with particular reference to amenity. Substantial agreement was also reached with the Forestry Commission, through the Forestry Consultative Panel, on the definition of zones within the Park where the Forestry Commission would undertake not to carry out planting, and of further zones where planting would only occur after consultation with the Committee. The Park Planning Committee for Dartmoor has now reached agreement with the South Western Electricity Board on detailed procedure for early informal consultation on proposals for overhead electricity supply lines within the Park, and its efforts to remove or mitigate disfigurements and advertising continued to meet with success. Anti-litter work further developed in the North York Moors, and in the Yorkshire Dales the West Riding Park Planning Committee reports further negotiations for public access to Barden Moor and Barden Fell.

The report of the Commission refers to new action to secure publicity for "The Country Code" and for national parks in general as well as to the campaign to abate the litter nuisance. Nearly four hundred development proposals were referred to it during the year, and the Commission does not conceal its disquiet at the granting of Ministerial consent for three major industrial undertakings in National Parks. These decisions must result in grievous damage to the landscape of the Snowdonia and the Pembrokeshire Coast Parks, and the particular and general issues involved are discussed in some detail in the report, while examples of other development issues handled during the year are given in appendixes. These three development proposals and a series of Acts with a direct bearing on the work of the Commission are regarded as the outstanding features of the year under review, but their implications are considered elsewhere.

* Ninth Report of the National Parks Commission for the year ending September 30, 1958. Pp. iv+79+8 plates. (London: H.M. Stationery Office, 1958.) 5*s*. 6*d*. net.

MAGNETIC FIELD OF THE EARTH

IN recent years the maintenance of the Earth's magnetic field has generally been ascribed to dynamo interaction between the field and convective motions in the Earth's core. Such an explanation receives support from the relatively rapid fluctuations in the field and its apparent reversals during geological times. However, theoretical investigations of the suggestion have met considerable difficulties. The field is supposed to be expanded in a series of harmonics, and in order to get soluble equations it is necessary arbitrarily to chop off the series at an appropriate point. Questions of convergence arise, and though the work of Bullard and Gellman, using all the resources of an electronic computer, made the convergence appear plausible, it could do no more.

A recent paper by A. Herzenberg* has discussed a dynamo model for which the question of convergence can be decisively answered. He represents the Earth by a large solid conducting sphere; two eddies in its interior are represented by smaller solid conducting spheres with their centres some distance apart, and which are constrained to rotate uniformly around diameters. The smaller spheres are in electrical contact with the material of the larger one, in which they are imbedded.

The system operates as a self-exciting dynamo if the angular velocities of the inner spheres are sufficiently great, and their axes of rotation are suitably oriented. The mechanism of dynamo maintenance is roughly as follows. The rotation of the first sphere twists the lines of magnetic force which penetrate the sphere, and generates a magnetic field large compared with the exciting field, the lines of force of the induced field being circles around the axis of rotation. This induced field is propagated through the surrounding material to the vicinity of the second sphere, where it provides a seed field

* *Philosophical Transactions of the Royal Society of London*, A, **250** (21 August, 1958): Geomagnetic Dynamos. By A. Herzenberg. Pp. 543–585. (London: Royal Society, 1958.) 13*s*.

which is similarly twisted by the rotation of that sphere and provides a much larger field with lines of force around the axis of rotation. This induced field in its turn is propagated back to the first sphere, where it provides the primary field which is twisted by the rotation of the latter. With roughly half the possible directions of the axes of rotation, the dynamo interaction amplifies the existing field. Herzenberg finds it necessary to discuss the reflexion of magnetic fields at the boundary of the large sphere, but it is difficult to believe that this can have any decisive importance to maintenance of the dynamo.

Herzenberg's mechanism possesses definite advantages from the mathematical point of view. If the distance between the centres of the smaller spheres is sufficiently great, the higher-order harmonics of the field which is induced by the rotation of one sphere are strongly attenuated before they reach the other sphere. This ensures the convergence of the expansions used by Herzenberg; a large part of his paper is, in fact, concerned with the convergence. The mechanism also has the advantage that the method of feedback is clearly evident; in Bullard and Gellman's work the same mass of fluid partook of two different sorts of motion at the same time, and it was virtually impossible to separate the effects of the two motions.

Like other earlier workers, Herzenberg made no attempt to consider the reaction of the induction process on the motion which causes it, and indeed his mechanism does not lend itself to considering such a reaction. The reaction must clearly be important, and be responsible for the tendency for the Earth's magnetic axis to approximate to its axis of rotation. Thus the importance of Herzenberg's work is primarily not physical, but mathematical. It decisively clears up any lurking doubts about the dynamo theory due to defects of convergence in earlier discussions. In considering the physical picture it is now no longer necessary to worry lest deeper research may show that failures of convergence invalidate the whole dynamo hypothesis.

T. G. Cowling

RAILWAY ECONOMICS

ALTHOUGH it appeared after the House of Commons debate on December 11, when the Transport (Borrowing Powers) Bill received its second reading, the broadsheet, "Paying for the Railways" (No. 429. December 19, 1958), issued by Political and Economic Planning, throws much further light on the problem of the future of railways, reviewing briefly the origin of the financial difficulties of British Railways since the War, the policies recently proposed, including the problem of wages, and finally setting forth four possible alternative solutions. In moving the second reading of the Bill, Clause 1 of which extends the borrowing powers of the British Transport Commission by a further £600 million, the Minister of Transport and Civil Aviation, Mr. H. Watkinson, said that the crux of the problem was how the railway system of the Victorian age could streamline itself to fit the age of the motor-car and nuclear power. For the first forty-four weeks of 1958 merchandise traffic was 14 per cent below 1957 and 10 per cent on 1956. Nevertheless, the Commission was pressing on with modernization of heavy traffic, but it was inevitably slow and took long to come to fruition. By the end of 1958, fitted freight trains would represent 35 per cent of the whole and wagons fitted with continuous brakes number 270,000; 44,000 containers suitable for door-to-door carriage would be in use, 150 older marshalling yards would be closed and 27 new yards constructed. Each working day 4 million passengers and 1 million tons of freight were moved.

Mr. Watkinson said a severe fall in heavy freight traffic in the last two months of the year was the main cause of the deficit for the year, which is expected to be about £85 million. Transport of coal was at present down by about 500,000 tons a week; production of crude steel in 1958 was probably about 10 per cent lower than in 1957, and the Commission's report indicates a fall in receipts from coal and mineral transport of more than £600,000 a week on 1957, but assumes that this is a temporary decline, calling for temporary measures only.

Mr. Watkinson said that at his request the Commission had already initiated a full, detailed and urgent review of the whole modernization plan, taking account of both present and probable changes in traffic in the light of the probable level of activity in the coal industry, in view of competition from oil and future developments in nuclear energy. He hoped to lay the findings of this review before Parliament by the early spring. Meanwhile, with the Government's full support, the Commission was proceeding with more modernization on a narrower front. It proposed to concentrate resources for main-line electrification on the London Midland and Scottish line to Manchester and Liverpool and to accelerate its completion by several years. The introduction of diesel locomotives to eliminate the use of steam would be accelerated as quickly as possible on an area basis, particularly on routes north of Newcastle upon Tyne: by 1961 nearly 1,100 main line diesel locomotives would be in use. Multi-unit diesel trains would be doubled, from 2,300 to 4,600, by the end of 1961. As a result of these and other measures the Commission expected to achieve additional savings of at least £30 million in a full year. Although there had been a reduction in the labour force of 20,000 during the past year, this had been effected with proper agreements between the Commission and the trade unions. In replying on the debate, Mr. C. R. H. Nugent, Joint Parliamentary Secretary to the Ministry, referred to the encouraging position of passenger services, revenue for which in November 1958 showed an increase of £0·3 million on 1957. The Minister himself also referred to the success of some of the luxury trains and to the Commission's intention to pursue a more flexible policy in fares.

Dealing with the modernization programme, first published in 1955, the Planning broadsheet agrees that the most important feature, the gradual substitution of electric or diesel traction for steam locomotives, as well as the plans for extending automatic train control and colour light signalling, fitting

all goods trains with vacuum brakes, the improvement of express train services and provision of door-to-door containers, should both provide economies and improve the quality of passenger and freight services. If the expectations of the Commission are justified, the initial cost of the modernization programme should be covered by improved revenues, and there is no justification for slowing down the programme to remove an immediate financial predicament.

The broadsheet is more critical of the policy of cutting uneconomic services, and while some adaptation of railway services is obviously necessary in the light of those provided by road hauliers and road passenger undertakings, Political and Economic Planning does not consider it is always in the interest of the railways to cut their services to solve an immediate financial problem. In reducing the frequency of passenger services the railways are following a dangerous policy of reducing costs by lowering the standard of their service, and experiment with the variety of alternative means of curtailing losses is advocated. Rejecting as economically unsound a flat subsidy without any re-organization of the national transport system, it points out that the solution of allowing the railways to operate purely as a commercial undertaking would involve a break with their long tradition of public service obligations. Although this would probably not cause serious hardship because so many alternative forms of private transport are now available, it is politically controversial although economically sound.

That also applies to the solution by joint control of the transport system as a whole by the same undertaking, as was envisaged when the British Transport Commission was created. The merits of the transport structure which emerged from nationalizing road haulage and long-distance 'C' licence road transport, however, would depend on the way in which co-ordination plans were formulated and implemented. The solution suggested by J. R. Sargent as a solution to the problem of unremunerative public transport services depends on a compromise between a commercial undertaking and a public service with the merits of each clearly defined, and has the merit of being politically neutral on the question how far the railways should function as a public service, since the decision how many, and which, services should be subsidized is referred to another authority. It could be applied without imposing any drastic changes on the ownership of the rest of the transport sector. The choice between any of these solutions, however, involves first a Government decision whether it wishes unremunerative services to be continued. If so, the Government must decide how these services should be financed, and in choosing the method to be used, the effects on the efficiency of transport as a whole and on the current distribution of work between road and rail require careful examination. Finally, Political and Economic Planning insists that decisions on these matters are urgent.

POSSIBLE ENZYMIC MECHANISM FOR THE DEVELOPMENT OF RESISTANCE AGAINST FLUOROURACIL IN ASCITES TUMOURS

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THE uracil analogue 5-fluorouracil was introduced by Heidelberger *et al.*[1] as an antimetabolite inhibiting tumour growth. In extensive metabolic studies[2–5] it was demonstrated that the pyrimidine was incorporated into ribonucleic acid of both normal tissues and tumours and, furthermore, that the compound inhibited the incorporation of labelled formate and uracil into deoxyribonucleic acid-thymine of Ehrlich ascites cells both *in vivo* and *in vitro*. The latter finding together with similar results by Eidinoff *et al.*[6] suggested a block in the methylation of deoxyuridine-5′-phosphate. Cohen *et al.*[7] recently demonstrated such an inhibition of thymidine-5′-phosphate synthetase from *E.coli* by 5-fluorodeoxyuridine-5′-phosphate.

These studies indicate two points at which the fluoropyrimidine might interfere with nucleic acid metabolism[1,5]: (1) inhibition of synthesis of deoxyribonucleic acid through the inability of the cells to synthesize thymine; (2) formation of a 'fraudulent' ribonucleic acid containing fluorouracil in place of uracil. Both mechanisms seem to require a transformation of the fluoropyrimidine to the nucleotide stage, and such transformations to fluorouridine phosphates and fluorodeoxyuridine-5′-phosphate, respectively, were also observed to occur in the ascitic cells[3,5]. In line with this idea is also the demonstration that in several tumours 5-fluorouridine and/or 5-fluorodeoxyuridine had a considerably higher tumour-inhibiting activity than the free pyrimidine[8].

Fluorouracil also strongly inhibits uridine phosphorylase[9] and thus inhibits synthesis of ribonucleic acid from uracil. This type of inhibition might also contribute to the carcinostatic activity of the compound.

One of our laboratories has for some time been interested in the utilization of uracil for synthesis of nucleic acid as an alternative mechanism for pyrimidine synthesis[10]. It was found that the Ehrlich ascites tumour possessed relatively high activities of the enzymes uridine phosphorylase and uridine

kinase which, by their combined action, transform uracil to uridine-5′-phosphate[11]:

$$\text{uracil} + \text{ribose-1-phosphate} \rightleftharpoons \text{uridine} + \text{phosphate} \quad (1)$$

$$\text{uridine} + \text{adenosine triphosphate} \rightarrow \text{uridine-5′-phosphate} + \text{adenosine diphosphate} \quad (2)$$

It was also found that these two enzymes occur at much higher concentrations in the tumour than in mammalian liver[12] and in most other normal tissues[13].

In the Ehrlich ascites tumour, uracil is also transformed to deoxyuridine-5′-phosphate through the combined action of deoxyuridine phosphorylase and deoxyuridine kinase:

$$\text{uracil} + \text{deoxyuridine-1-phosphate} \rightleftharpoons \text{deoxyuridine} + \text{phosphate} \quad (3)$$

$$\text{deoxyuridine} + \text{adenosine triphosphate} \rightarrow \text{deoxyuridine-5′-phosphate} + \text{adenosine diphosphate} \quad (4)$$

The enzymes catalysing reactions 1 and 3, respectively, have been partially separated by ammonium sulphate fractionation[14], while there is only indirect evidence that reactions 2 and 4 are catalysed by two different enzymes.

Fluorouracil can be substituted for uracil in reactions 1 and 2 and thus give rise to fluorouridine-5′-phosphate[9]. A similar substitution of uracil in reactions 3 and 4 has not yet been demonstrated, but seems very likely.

It is well known that tumour cell populations can become resistant against different types of antimetabolities when exposed to prolonged treatment. It has been suggested that such changes have a mutation-selection basis, in analogy with similar events in microbial populations[15]. Very little is known about the biochemical nature of such hypothetic mutations. The purpose of our investigation was to determine whether any change occurs in the activities of some of the enzymes described above concurrently with the development of resistance against fluorouracil. We were particularly encouraged by the report of Heidelberger *et al.*[8], who mentioned the occurrence of a line of an Ehrlich ascites tumour, resistant to fluorouracil but susceptible to fluorouridine, and also by experiments with bacterial mutants resistant against azauracil[16] and 6-mercaptopurine[17].

Fluorouracil-resistant lines were developed from the Ehrlich ascites tumour and the ascitic form of lymphoma *L* 1210 by serial transfer under prolonged treatment. Heterozygous mice were inoculated with 10^6 cells of the Ehrlich tumour while the same number of *L* 1210 cells were injected into the peritoneal cavity of *DBA*/2 mice. The animals were treated by intraperitoneal injections of 20 mgm./kgm. fluorouracil every second day, starting the day after inoculation. As a rule, 10 mice were treated while 5 were left as untreated controls. As soon as any of the treated animals developed ascites, they were punctured and about 1 ml. of fluid was collected. After appropriate cell counts have been made, 10^5 cells were inoculated to a new recipient group, consisting of 15 mice. In this new group, 10 mice were again treated while 5 served as controls. If ascites became available in the treated group, the procedure was repeated in the same way.

Three independent lines of the Ehrlich ascites tumour were treated. Considerable inhibition was obtained in the first generation, in agreement with the findings of Heidelberger *et al.*[1]. Two lines did not show any tendency to increased resistance and were lost after 3 and 5 passages, respectively. A third line showed a marked increase in resistance

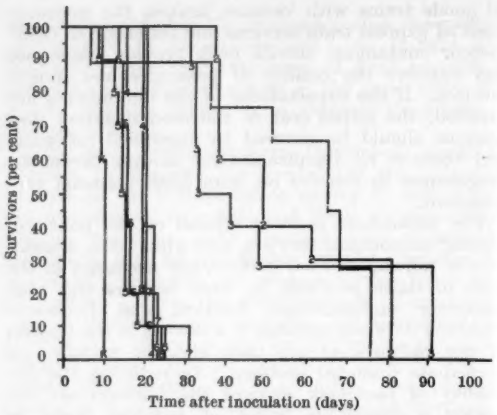

Fig. 1. Survival curves of fluorouracil-treated mice inoculated with untreated Ehrlich ascites tumour cells (group *K*) and with cells carried under prolonged treatment for 1–8 passages (groups 1–8). *K*, control; 1–8, first to eighth treated generations

during prolonged treatment (Fig. 1). The increase in resistance was particularly pronounced between the third and fourth transfer, and by the fifth passage resistance was nearly complete, although not absolute, as indicated by the survival curves of Fig. 1. No additional increase in resistance has been observed during six consecutive passages under treatment.

L 1210 was much less sensitive than Ehrlich but showed, nevertheless, a slight but definite inhibition during fluorouracil administration. This inhibition decreased in the course of prolonged treatment and was entirely abolished after six passages (Fig. 2).

The enzymes of reactions 1–4 were assayed in extracts of acetone powder and in tumour homogenates[12,13]. Table 1 shows that, within the limits of our methods, both uridine and deoxyuridine phosphorylases were absent from the resistant Ehrlich ascites cells. Some decrease in uridine kinase activity also occurred whereas deoxyuridine kinase activity showed little changes.

In another experiment intact Ehrlich ascites cells were incubated with uracil labelled with carbon-14 at

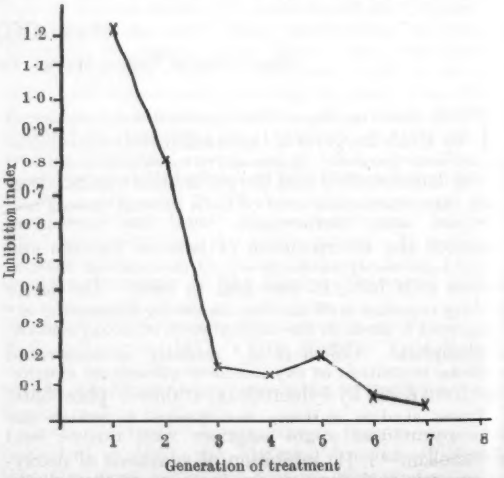

Fig. 2. Inhibition index (mean survival time of treated mice−mean survival time of controls/mean survival time of controls) of DBA/2 mice inoculated with lymphoma L1210, under consecutive passages in the presence of fluorouracil treatment

Table 1. Determination of Enzyme Activities in a Normal and Fluorouracil-Resistant Strain of Ehrlich Ascites Tumour

	Acetone powder extracts		Homogenates	
	Normal	Resistant	Normal	Resistant
Uridine phosphorylase	74	< 0·5	11	< 0·5
Uridine kinase	80	25	5·3	2·7
Deoxyuridine phosphorylase	30	< 0·5	3·6	< 0·5
Deoxyuridine kinase	1·5	2·7	—	—

The values are given as mμmoles of product per mgm. of acetone powder or per mgm. wet weight (10 per cent homogenates) formed during 15 min. incubation at 37°.

Table 2. Analysis of Acid-soluble Fraction from Intact Ascites Cells after Incubation with Uracil labelled with Carbon-14

	Normal cells	Resistant cells
Uracil	540	370
Uridine	1·6	—
Uridine-5′-phosphates	151	< 2
Deoxyuridine-5′-phosphate	0·8	—
Thymidine-5′-phosphates	1·5	—

The values represent mμmoles of the different compounds in one ml. of ascitic cells.

37° for 30 min. in Tyrode solution. Analysis of the acid-soluble fraction (Table 2) showed that the normal and resistant cells were permeable to uracil to about the same extent. In the normal cells uracil also gave rise to uridine-5′-phosphate. Besides small amounts of uridine, deoxyuridine-5′-phosphate and thymidine 5′-phosphates were also formed by the normal cells. No significant amounts of any of these compounds were found in the resistant tumour.

Enzyme determinations were also carried out in a normal and fluorouracil-resistant line of lymphoma *L* 1210 (Table 3). The normal tumour is much less susceptible to inhibition by fluorouracil than the Ehrlich ascites tumour, and it is interesting that in the normal lymphoma both phosphorylases show a relatively low activity. The changes in enzyme activities from the normal to the resistant lymphoma are less spectacular than in the Ehrlich ascites tumour, but it is nevertheless evident that a considerable decrease in uridine phosphorylase and kinase activities had taken place.

Table 3. Determination of Enzyme Activities in Acetone Powder Extracts of a Normal and a Fluorouracil-resistant Strain of Lymphoma 1210

	Normal	Resistant
Uridine phosphorylase	10	5
Uridine kinase	67	16
Deoxyuridine phosphorylase	4	4
Deoxyuridine kinase	3	3

For explanation of values see Table 1.

In summary, our experiments with the Ehrlich ascites tumour indicate that during the development of resistance the cells lost the capacity to transform uracil (and therefore also fluorouracil) to the riboside and the deoxyriboside. The fact that both enzymes are missing from the tumour might mean that the cells must lose both the ability to incorporate fluorouracil into ribonucleic acid (which proceeds via the riboside) and the ability to form fluorodeoxyuridine-5′-phosphate (which proceeds via the deoxyriboside) before a complete resistance against the drug has developed. Alternatively the loss of both enzymes might take place simultaneously through a single genetic event, even though the two enzyme activities are represented by two different proteins, which can be separated from each other by ammonium sulphate fractionation.

It is hoped that a choice between these two alternatives will be possible through an analysis of the enzyme pattern of partially resistant lines. Further experimentation is also required before one can decide whether resistance against fluorouracil in the Ehrlich ascites tumour generally is due to a lack of one or several of the enzymes necessary for the transformation of the pyrimidine to nucleotides, or whether such a mechanism only represents one of several possibilities.

This work has been supported by research grants from the Swedish Cancer Society, the Lady Tata Memorial Trust and the Damon Memorial Fund for Cancer Research. We wish to thank the Hoffmann-La Roche Co. for a generous gift of 5-fluorouracil.

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ELECTRON-MICROSCOPIC STUDY OF FINBACK WHALE MYOGLOBIN CRYSTALS

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THE visualization of the molecular arrangement in crystals of virus proteins of high molecular weight has been successfully achieved by Wyckoff and Labaw[1]. More recently, Dawson and Watson[2] studied the crystal structure of the protein ribonuclease, which has a lower molecular weight, using carbon replicas, and in addition, direct examination. These two methods of examination have also been used in the study of myoglobin described here.

The protein myoglobin has been studied in detail by X-ray analysis, and, with the information obtained, it has been possible to build up a three-dimensional

model of the molecule[3]. The dimensions of the molecule are 43 A. × 35 A. × 23 A., well within the limit of resolution of the electron microscope and existing specimen preparation techniques. It would therefore seem possible that these molecules, or at least structures relating to the unit cell, could be seen in crystalline myoglobin. The dimensions of any such structures observed could then be related to the X-ray results.

The two possible approaches to the electron microscopy of protein crystals have already been mentioned. The specimen can either be examined in transmission, or by means of replicas, which give a picture of the surface topography. In the case of transmission, very thin crystals must be used to permit penetration by the electron beam. With replicas, a technique permitting the attainment of reasonably high resolution is required. Electron micrographs of the myoglobin lattice have been obtained by both methods, but the most useful information has so far come from surface replicas.

Myoglobin can be obtained from many different animals, and crystallizes in different forms[4]. In this examination, the material was obtained from the finback whale and recrystallized from sodium and potassium phosphates, the resulting crystals being known as type *F* myoglobin. The X-ray analysis has been described by Kendrew and Pauling[5]; the crystal morphology given by them is as follows.

The crystal habit is orthorhombic, the crystals being in the form of six-sided plates with the flat face the {001}. There are two inclined side faces which are {101}, and the remaining four vertical side faces are {210}, as shown in Fig. 1. It can be seen that this form of crystal is particularly suitable for electron microscopy since the {001} face will be predominant and easily recognizable, and the {210} will be distinguishable from the {101}.

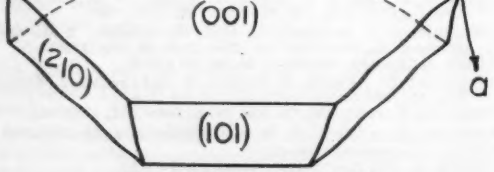

Fig. 1. Type *F* myoglobin crystal

The lattices of many proteins shrink when the crystals are removed from the suspending liquid and dried. This is the case with myoglobin; the following cell constants are given by Kendrew and Pauling[5]. In wet conditions $a = 97{\cdot}4$ A., $b = 39{\cdot}8$ A., $c = 42{\cdot}5$ A. In dry conditions $a = 88$–94 A., $b = 36$–37 A., $c = 35$–38 A. The reason why a range of values is given is that the degree of shrinkage in dry crystals is not constant.

Before proceeding with the preparation of replicas, it was necessary to separate the crystals from the ammonium phosphate solution in which they were suspended and to mount them on a suitable substrate without resuspension in any other liquid medium. This precaution was taken in order to minimize disturbance of the molecular organization. The operation was carried out by placing a drop of the suspension on a thin, freshly cleaved mica sheet which had been pierced with a needle. The underside of this sheet was pressed against a filter paper, and the suspending liquid drained through the hole, leaving the crystals behind.

Fig. 2. {001} and {210} faces of a type *F* myoglobin crystal. Platinum/iridium/carbon replica (angle 2 : 1) The larger spacing is on the {210} face. (× 200,000)

Replicas were made by placing the mica strip in a vacuum plant and depositing a thin film containing platinum, iridium, and carbon using an evaporating technique described elsewhere[6,7]. The combined film and crystals were floated on to water, where the crystals dissolved, leaving a replica ready for mounting on support grids. The simultaneous evaporation of the three elements provided an amorphous deposit containing very sharp shadows (the angle being 2 : 1). Though the same structure could be observed using conventional platinum metal shadowing, the result was somewhat sharper using the technique described.

Electron micrographs were obtained of the three crystal faces mentioned, and of these, the {001} and {210} showed a periodic structure (Fig. 2). This consisted of dark lines parallel to the *b* and *c* axes respectively. A close examination of some micrographs indicated that the dark lines were grooves rather than steps. The spacings were measured over a number of micrographs of different crystals and gave an average value of 88·5 A. for the {001} face and 114·5 A. for the {210}. Assuming that the grooves correspond to the unit cell structure, the spacings observed on the {001} face should be equal to *a* and the spacing on the {210} to its projection, which is $\sqrt{a^2 + 4b^2}$. The value of *b* obtained by equating this expression with the observed 114·5 A. is 36·5 A. The experimental values $a = 88{\cdot}5$ A. and $b = 36{\cdot}5$ A. are consistent with the unit cell dimensions of the dry crystals.

While no periodic structures from which the value of *c* could be calculated have so far been observed, an approximate value can be estimated from the layer growth structures which have been observed on the

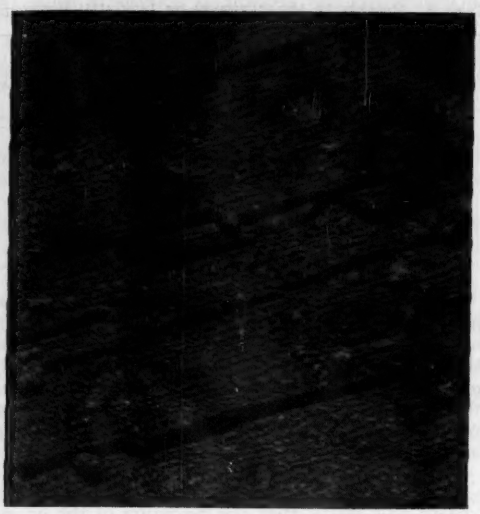

Fig. 3. {001} face of a type *F* myoglobin crystal showing layer growth. Platinum metal shadowed (angle 2 : 1) carbon replica. (× 125,000)

{001} faces (Fig. 3). The thicknesses of the layers can be calculated from lengths of shadows and should correspond to an integral number of *c* spacings. A large experimental error arises because the crystals may be tilted on the mica sheet, so giving a range of different shadowing angles. The value obtained in this way is (43 ± 15) A. Taking into account the experimental error, this result is consistent with the *c* dimension for dry crystals.

This method for measuring the *c* dimension is more accurate if the step consists of a large number of units (at least 10) so that the step height is large (at least 200 A.), as is the case with steps on cleaved sucrose[7].

It has already been mentioned that the myoglobin lattice can be seen in direct electron micrographs of thin regions of the crystal. This fact, together with the results of Dawson and Watson[2], indicates that it is possible to examine the lattices of easily denatured materials directly. The mechanism of image formation is similar to that proposed by Menter[8] for platinum phthalocyanine and the mineral sodium faujasite.

The results obtained here for the cell dimensions of type *F* myoglobin agree well with the results of Kendrew and Pauling. This indicates that the electron microscope can be used for providing reliable data for the evaluation of the crystal structures of materials difficult or impossible to study by X-rays.

I am grateful to Dr. J. C. Kendrew for supplying the myoglobin, Mr. R. Phillips and Dr. J. S. Halliday for their help and advice, and Dr. T. E. Allibone, director of the Research Laboratory, Associated Electrical Industries, Ltd., for permission to publish this article.

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STRUCTURE OF SOME HYDROXIDES AND HYDROUS OXIDES

Binding of Water in some Hydroxides and Hydrous Oxides

INFRA-RED absorption spectra of hydrated aluminium oxides have recently[1] been interpreted as follows: these oxides contain hydroxyl groups, and on rehydration of the anhydrous oxides, these may be built into the lattice. In most cases no change in lattice of the oxides can be observed. The experiments were extended to compounds of the systems manganese dioxide/water[2], silicon dioxide/water and ferric oxide/water[3,4], and the presence of hydroxyl groups in these substances has been proved in the same way. We were interested in the brown precipitate formed in solutions of iron (III) salts by adding hydroxyl ions. These precipitates are either (incorrectly) formulated as $Fe(OH)_3$, or supposed to be iron (III) oxide with a very large specific surface[5]. In Fig. 1 the infra-red spectrum of a sample containing 15·1 per cent water is given, obtained from a solution of iron (III) nitrate by precipitation with ammonia, compared with the spectrum of water.

The centre of gravity of the hydroxyl band of water is located at 2·95μ. However, the centre of gravity of the band in I has moved to longer wave-lengths, between 3·1 and 3·2μ. Also an asymmetrical broadening to longer wave-lengths is observed. In I, therefore, we assume that the hydroxyl groups form O—H . . . O hydrogen bonds which are, in part, very strong because of the shorter O—H—O distance; the stronger these bonds are, the longer the OH absorption wave-length[6].

Proton magnetic resonance measurements have been carried out on aluminium and iron hydroxides and on manganese oxide hydrates (see following

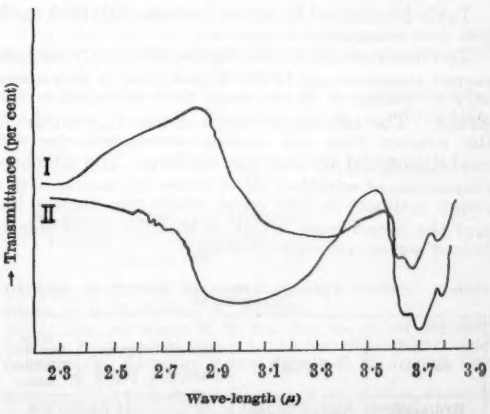

Fig. 1. Infra-red spectra (lithium fluoride prism, dispersion in 'Nujol') of iron (III) hydroxide ($Fe_2O_3 \cdot 1{\cdot}49\ H_2O$) and the spectrum of water

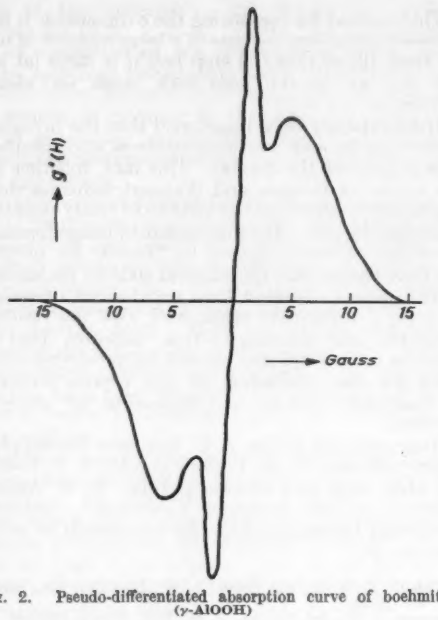

Fig. 2. Pseudo-differentiated absorption curve of boehmite (γ-AlOOH)

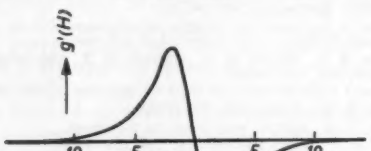

Fig. 3. [Pseudo-differentiated absorption curve of an iron (III) hydroxide (Fe_2O_3. 2·72 H_2O)

communication). All aluminium oxides showed a broad line with a superimposed narrow line which is thought to be due to adsorbed water (Fig. 2). Table 1 summarizes the results for aluminium hydroxides. In general, the absorption signals of iron hydroxides and manganese oxides consist of a narrow line which is broadened at the base (Fig. 3).

Table 2 contains the results for iron (III) hydroxide gels and manganese oxides.

To obtain an absorption signal sufficiently large to permit measurement of the broad lines, it was necessary to choose a rather large field modulation (1·6 gauss). The tabulated values of the line-widths of the narrow lines are mainly determined by this modulation and are therefore too large. The tabulated percentage of adsorbed (free) water represents only a rough estimate in the cases where the narrow line and the broad base, which is thought to be due to bound water, strongly overlap.

Table 1. Proton Magnetic Resonance Results on Aluminium Hydroxides

Sample	Formula	Line-width (gauss) Narrow	Broad	Mole per cent 'adsorbed' water
Hydrargillite	Al_2O_3 3·01 H_2O	2	14·3	0·8
Bayerite	Al_2O_3 3·18 H_2O	2·6	11·7	6
Boehmite	Al_2O_3 1·06 H_2O	2·6	10·5	6

Table 2. Results of Measurements on Iron (III) Hydroxide Gels and Manganese Oxide Hydrates

Formula	X-ray data	Line-width (gauss)	Base-width (gauss)	Mole per cent 'adsorbed' water
Fe_2O_3 2·72 H_2O	Some broadened lines of α-Fe_2O_3	4	29	55
Fe_2O_3 1·72 H_2O	γ-FeOOH	4	29	40
Fe_2O_3 1·96 H_2O	amorphous	3·9	~33	43
Fe_2O_3 1·2 H_2O	amorphous	5·3	~25	25
$MnO_{1\cdot93}$ 0·86 H_2O	δ-MnO_2	2·1	11	60
$MnO_{1\cdot82}$ 0·21 H_2O	γ-MnO_2	2·2	25	40

Table 2, as well as the infra-red spectra, show the impossibility of isolating precipitates with the formula $Fe(OH)_3$ from solutions of iron (III) salts by the addition of hydroxyl ions. Probably the hydroxyl groups condense with the formation of water, and this may occur during aging or heating via compounds with gradually decreasing water content, until the water-free end-product, α-Fe_2O_3, is formed.

On one hand, the existence of hydroxyl groups in manganese oxide supports the suggestion of Feitknecht and Marti[7] that the deviation of the oxygen content from the ideal stoichiometric formula $MnO_{2\cdot00}$ arises from the replacement of oxygen ions by hydroxyl ions. On the other hand, it is difficult to consider samples with a higher hydroxyl content, for example δ-MnO_2, as polymorphic modifications of manganese dioxide.

Our results on the compounds belonging to the oxide/water system suggest two new groups of hydroxides: (1) *condensed hydroxides* resulting from the elimination of water, for example, iron (III) hydroxides, silicic acid; (2) *non-stoichiometric hydroxides* with non-stoichiometric hydroxyl contents, for example, aluminium hydroxides with different hydroxyl contents in identical lattices.

The proton magnetic resonance experiments were carried out at the Philips Research Laboratories in Eindhoven.

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Positions of Protons in Aluminium Hydroxides derived from Proton Magnetic Resonance

Proton magnetic resonance measurements have been carried out on some aluminium hydroxides with the object of ascertaining whether the water was present in free (for example, adsorbed) or in bound form (see preceding communication). All samples consisted of powdered material. The measurements were carried out at room temperature with a simple nuclear magnetic resonance spectrometer of the autodyne type (to be published). The

resonance absorption of protons was determined at a frequency of 17·5 Mc/s.

From the second moment of the absorption line $g(H)$ defined as:

$$\int_{-\infty}^{+\infty} g(H)\,(H - H_0)^2 dH \Big/ \int_{-\infty}^{+\infty} g(H) dH$$

information may be obtained about the positions of the protons in the crystal lattice[1]. In Table 1 the calculated values of the second moment are given, assuming a certain model as well as the second moment derived experimentally from the broad line (see preceding communication). The second moments of the aluminium oxide hydrates were calculated as follows.

Table 1. Calculated and Experimental Second Moments of the Aluminium Hydroxides Studied

Sample	Second moment calculated (gauss²)	Second moment experimental (gauss²)
Hydrargillite	26·0	26·5 ± 1·2
Bayerite		18·8 ± 1·0
Boehmite	19·0 – 19·2	18·2 ± 1·0

Hydrargillite ($\gamma Al(OH)_3$). The structure of hydrargillite has been determined by Megaw[2]. In this structure the aluminium atoms are located between two planes of oxygen atoms which are close-packed and surround the aluminium atoms octahedrally. These planes form an *AB—BA—AB—B . . .* sequence. According to Megaw, the protons are found between these 'sandwiches'.

Fig. 1 shows the octahedron triangles formed by the oxygen atoms in one plane.

One may assume a model where the O—H bonds are directed from an oxygen atom in the lower plane to an oxygen atom in the upper plane in the next 'sandwich', but translated over one triangle side. In alternate triangles these OH bonds are pointing upward and downward (Fig. 1*a*). From this model a second moment of 26·0 gauss² is calculated (taking the OH distance equal to 0·96 A.). In a similar model (Fig. 1*b*), with the projections of the OH directions in the different triangles forming an angle of 120°, one obtains 29·4 gauss². In these models it is clear that there exists a special triangle in agreement with the X-ray data. It will be shown elsewhere that from other models a completely different value of the second moment is obtained. (For example, for the model suggested by Bernal and Megaw[3] the second moment is less than 15 gauss².)

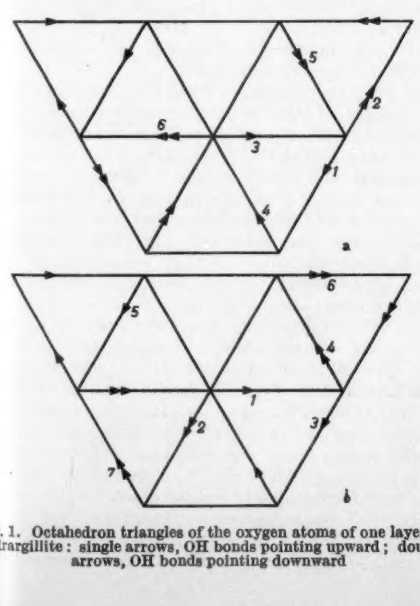

Fig. 1. Octahedron triangles of the oxygen atoms of one layer of hydrargillite: single arrows, OH bonds pointing upward; double arrows, OH bonds pointing downward

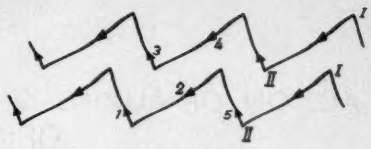

Fig. 2. Zigzag chains of the OH bonds in boehmite in the parallel position

The calculations on hydrargillite were carried out starting from a regular hexagonal structure. In practice, the octahedra are slightly deformed; the effect upon the second moment is small.

Boehmite ($\gamma AlOOH$). The structure of boehmite has been determined by Millikan and McAtee[4]. The OH directions form zigzag chains between the planes of the oxygen atoms (Fig. 2). Nakamoto, Margoshes and Rundle[5] have correlated the OH-stretching frequency and the O—H . . . O distance in different compounds. They give a graph of O—H distances against corresponding O—H . . . O distances. In this graph an O—O distance of 2·70 A. corresponds to an O—H distance equal to 0·98 A. With an assumed OH distance of 0·98 A. a second moment of 19·0 gauss² is obtained in the case of parallel OH bonds in successive chains, whereas for anti-parallel OH bonds one obtains 19·2 gauss². It is thus not possible from values of the second moment alone to distinguish between these models.

After the work described here had been completed, a recent paper of Holm *et al.*[6] came to our attention, giving experimental data and calculations of the structure of boehmite in complete agreement with our results.

Bayerite (α-$Al(OH)_3$). The structure has been determined by Yamaguchi and Sakamato[7]. They assume a model not unlike the structure of brucite, $Mg(OH)_2$, but without one-third of the metal atoms. However, the calculation of the second moment for this structure leads to values larger than 33 gauss². (The OH distance was assumed to be 0·98 A.)

The discrepancy between the experimental and calculated second moments is so large as to suggest a completely different structure.

We thank Prof. O. Glemser, of the Anorganisches Chemisches Institut der Universität at Göttingen, for preparing the samples.

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ACTION OF AUXINS ON *ACETABULARIA* AND THE EFFECT OF ENUCLEATION

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THE effect of auxins on algæ has never been as clear-cut as on higher plants. While some positive effects, both on multiplication of unicellular forms and on organ formation in larger algæ, have been demonstrated, many of the results have been uncertain or even conflicting. In the case of *Chlorella*, some, but not all, of the disagreement may have been due to the use of ethanol as solvent for the added auxin, since concentrations of ethanol as low as 0·01 per cent markedly increase the growth[1,2]. However, there are other sources of variation; Elliot[3] found indoleacetic acid, made up without alcohol, to promote the growth of *Euglena gracilis* at 0·1–1·0 mgm./l., while in our own (unpublished) experiments no effect could be found at any concentration with autotrophic or mixotrophic nutrition. Other factors were uncovered by Algeus[4], who has made the most thorough study to date with unicellular forms. He found indoleacetic acid (made up without alcohol) caused marked increases in cell number in two strains of *Chlorella* and in *Scenedesmus obliquus*, but not in others. There was no increase in cell size. Naphthaleneacetic acid and indole-3-butyric acid were much less effective than indoleacetic acid. He observed that the stimulation in indoleacetic acid came to an end after about six days, and traced this to photo-destruction of the auxin and consequent formation of an inhibitory product; the product of the action of hydrogen peroxide on indoleacetic acid was also inhibitory. Algeus and other workers have also reported that when sugar was added to the medium the growth is better, but the promoting effect of auxin disappeared. Presence or absence of sugar, like that of ethanol, may explain some, though not all, of the earlier discrepancies. A comparable influence of soil extract has been noted in our work reported here.

Work on the larger algæ is somewhat more definite. The growth of germinating zygotes of *Ulva*, zoospores of *Enteromorpha*, and sporelings of *Fucus* and *Ascophyllum* are all reported to be promoted by indoleacetic acid[5,6], but in the case of *Fucus* sporelings iodoacetic acid was about equally effective; the stock solutions were made up with alcohol in this case[6]. In the green alga *Rhizoclonium*, indoleacetic acid caused marked elongation, the mean cell-length being doubled at the optimal concentration, which was 10^{-9} *M*; the dry weight showed a smaller increase[7]. Again the stock solutions were made up in alcohol, which may vitiate these results. However, isolated apical segments of *Codium* gave a marked elongation response to 5 mgm./l. (3×10^{-5} *M*)[8] of indoleacetic acid, and this solution contained no alcohol. Organ formation may be promoted, too; the development of rhizoids on the thallus of *Bryopsis*[9] and *Enteromorpha*[10] was strongly promoted by indoleacetic acid, though Jacobs's method of application (suspension of a few indoleacetic acid crystals in the sea water) probably involved very high concentrations[9]. Indoleacetic acid hastened both shoot and rhizoid development on separated internodes of *Nitella*[11,12], but the action of other auxins was equivocal: naphthaleneacetic acid hastened formation of rhizoids but not that of shoots, indolebutyric acid hastened that of shoots but not that of rhizoids, while 2,4-dinitrophenol hastened neither. The effects were quite non-specific since riboflavin and ascorbic acid were about equally active; pyridoxin and niacin were also active on rhizoid formation. Another apparently non-specific effect is that of indoleacetic acid, kinetin or adenine in promoting the initiation of filaments on the thallus of *Ulva lactuca*[13]. Recently, Hustede[14] has found a striking effect of indoleacetic acid in promoting the formation of zoospores of *Vaucheria* and causing its antheridia to grow into vegetative tissue. Tryptophan has the same effect, but indolecarboxylic acid acts in the opposite direction, suppressing the formation of zoospores and promoting the formation of oogonia. Finally, Dao[15] has reported marked acceleration of growth by indoleacetic acid in *Acetabularia mediterranea*; but the effects varied with the season. Later, however, she could not confirm these results, either with indoleacetic acid or naphthaleneacetic acid, though high concentrations of the former or tryptophan still promoted growth somewhat[16]. The solutions were not changed during the experiments and became brownish due to photodestruction (cf. ref. 4). As actual growth data were not given, and the ranges of growth-rate quoted were higher for her plants growing in unsupplemented sea water than for those of other workers in the more favourable Erdschreiber solution, it is difficult to appraise this work.

The general impression from these studies is that some aspects of algal growth are indeed promoted by auxins under some conditions, but that these conditions are not well defined, the specificity of the action is uncertain and the effects are subject to wide variation. Since many processes in algæ are fundamentally the same as in higher plants, and since there is no special reason for believing that the processes of growth constitute an exception, promotion by auxin should be expected. It seemed, therefore, desirable to re-examine the problem. In the microscopic forms, cell multiplication is the only convenient criterion for growth, whereas in higher plants the most prominent effects of auxin are on cell enlargement and organ formation. For this reason an alga with large cells was preferable. The specially favourable structure and long growing period of *Acetabularia*, as well as the marked morphogenetic capacities of its parts, which have been the subject of numerous investigations, made it peculiarly well adapted for the purpose.

Plants of *Acetabularia mediterranea*, 6–9 months old and 10–30 mm. in length, were the experimental material. They were grown in Erdschreiber solution,

and the experiments were carried out in artificial-light cabinets at 20° C. Erdschreiber, Schreiber solution, or sea water were used as a medium, and indoleacetic acid, naphthaleneacetic acid, or in a few cases other compounds, were used as auxins. The stock auxin solutions, from which dilutions were prepared, were made up in sea water and adjusted to *p*H 8·0–8·2.

Two different and independent effects of auxins on *Acetabularia* have been established in this work. They are complexly interrelated with both the simultaneous and the previous exposure of the plants to light, as well as with the nutrient solution used. In the first place, indoleacetic acid promotes elongation of the stalk. The effects range up to nearly 100 per cent increase: they can be observed in both bright and medium light, and are best seen in Schreiber's solution. The optimal concentration of indoleacetic acid is from 10^{-5} to 10^{-6} *M* (1·75–0·175 mgm./l.). An example is shown in Table 1.

Table 1. GROWTH OF INTACT *Acetabularia* PLANTS IN INDOLEACETIC ACID

Bright light, 20° C., Schreiber solution. Plants which had formed caps at 25 days omitted

Concentration of indole-acetic acid (*M*)	0	10^{-6}	10^{-5}	10^{-4}
Initial length (mm.)	19·8	20·3	19·0	19·9
Increase in next 11 days (mm.)	1·7	2·8	4·4	4·5
Increase in following 14 days (mm.)	5·2	5·0	8·7	7·2
Total increase in 25 days	6·9	7·8	13·1	11·7

In the second place, indoleacetic acid promotes the formation of the 'cap' (the organ in which the reproductive cysts are formed later). This also can be observed best in Schreiber solution, but has been noted to a lesser extent in Erdschreiber, in which all the plants, controls included, form caps more readily. The optimum concentration of indoleacetic acid for cap formation is in most experiments 10^{-4} *M*, that is, 100 times as great as for elongation. One of several comparable experiments is shown in Fig. 1.

Naphthaleneacetic acid also acts powerfully on cap formation; its optimum concentration is at 10^{-5} *M*, while 10^{-4} *M* is inhibitory and eventually toxic. It is thus clearly effective at lower concentrations than indoleacetic acid. In promoting stalk growth its optimum concentration is 10^{-5}–10^{-6} *M*, though it is apparently somewhat less potent than indoleacetic acid.

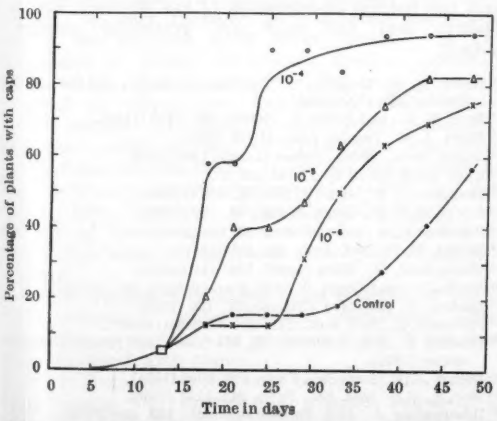

Fig. 1. Time course of cap formation in *Acetabularia mediterranea* at 20° and about 100 ft. candles white light; in Schreiber solution and with three concentrations of indoleacetic acid, 10^{-4}, 10^{-5}, 10^{-6} *M*, renewed about every 7 days

A feature of the responses, both in stalk growth and in cap formation, is that they occur only after a considerable period of time, 10 days being about the minimum for a detectable effect. Since the *p*H of the suspending medium is about 8·2, a value at which indoleacetic acid and naphthaleneacetic acid are fully dissociated and therefore might perhaps be restricted in their entry, a study was made of the action of the neutral auxins methyl indoleacetate and indoleacetonitrile. However, while both these substances clearly promote cap formation, and in addition the nitrile promotes elongation, their action was found to be no more rapid than that of indoleacetic acid. Indeed, the elongation caused by the nitrile was not observed at all at 11 days, when indoleacetic acid had shown a pronounced effect, but was only seen after 28 days. The slow action of the acidic auxins is not, therefore, due to slow entry into the plant.

That the slow action is also not due to photo-destruction (cf. Algeus[4]) follows from the fact that the action of naphthaleneacetic acid, which is resistant to photo-destruction, is no more rapid than that of indoleacetic acid. To make this point certain, however, an experiment was carried out with the latter acid in which the solution was changed daily, instead of every 5–7 days as in the other experiments. There was no marked increase in the growth promotion, nor did it begin earlier. The slow reaction thus seems to be a characteristic of the system under study.

A substance which antagonizes the action of auxin in some assay systems, though not in all, is 2,3,5-triiodobenzoic acid. This compound was found to inhibit both elongation and cap formation. The effective concentration was 10^{-4} *M* and higher levels were toxic.

The isolated rhizoids (which contain the nucleus) behave somewhat differently. So far as auxin is concerned, the rhizoids are in most cases inhibited in elongation by added auxin at all levels down to 10^{-7} *M*. However, after the plants have been removed from the auxin solution and returned to unsupplemented Schreiber solution, they may afterwards show a striking growth promotion which lasts for several weeks. This is illustrated in Fig. 2. Such different behaviour to auxin by different parts *of a single cell* is of considerable interest.

The facts: (1) that the concentrations of auxin effective for the two actions are different and (2) that in some experiments, especially with methyl indoleacetate, cap formation was clearly promoted while elongation was not, suggest strongly that elongation and cap formation are independent processes. This supports previous conclusions as to their independence, based upon the evidence that cap formation is mediated by specific substances[17–19] and on the very different light-intensity requirements of the two processes[20].

It is well known that the addition of soil extract to sea water or to Schreiber solution ('Erdschreiber') promotes both growth and cap formation. This effect is evidently not the same as the action of auxin, as the following experiment shows. A group of plants in sea water with added naphthaleneacetic acid in a series of concentrations formed 55 per cent of caps in the optimal concentration (10^{-5} *M*)—a figure which

Fig. 2. Isolated rhizoids from plants pre-treated with indoleacetic acid 10^{-5} *M*, grown afterwards in Schreiber solution for 20 days

did not increase further in an additional 6 weeks. At this point Erdschreiber solution was added. Within one week the percentage of caps had risen to 90 per cent. Comparable increases occurred in the other concentrations. It is suggested that soil extract and auxin act upon essentially the same process but in different ways.

Some of our experiments point also to the probability that in bright light a growth-limiting factor is used up or destroyed, but that this factor can be synthesized from the constituents of Erdschreiber solution. This light-labile growth factor also cannot be identical with auxin.

Effect of Enucleation

Since in *Acetabularia* the single primary nucleus lies in the rhizoids, another, and a long-standing, problem of auxin action could be attacked. Many attempts have been made to demonstrate an action of auxin on *in vitro* systems, but always without success. In consequence, it appears that the intact cell is necessary for auxin action, and this has led to the speculation by one of us that the primary action of auxin may be exerted on the nucleus, which then secondarily modifies enzyme systems controlling growth. *Acetabularia* is one of very few organisms in which this proposal can be readily tested, because its enucleated cells can be easily prepared and they have been shown to survive well and even to grow. The action of auxin was therefore studied on enucleated *Acetabularia*. The part cut off in these experiments comprised the whole rhizoid plus about 1 mm. of stalk.

Enucleation slows down elongation very greatly. This fact, although mentioned by Hämmerling in 1934[17], does not seem to have been clearly brought out in subsequent work. However, the growth of enucleated plants is still readily measurable. From our experiments it seems clear that they still show some growth promotion in response to auxin, though the responses are smaller than those in intact plants. For example, elongation of enucleated plants (30 mm. long) in 3 weeks was increased from 2·6 mm. in the controls to 4·7 mm. in 10^{-4} *M* indoleacetic acid. Furthermore, the percentage of caps was increased from 14 (controls) to 44 (indoleacetic acid) in the same period. As an average of four experiments in Schreiber solution, cap formation in enucleated controls was 14 per cent and in optimal auxin 31 per cent (final figures reached); in an additional two experiments, however, there was no response to auxin. On the whole, it seems clear that indoleacetic acid does promote cap formation in enucleated plants, and it increases not only the rate of formation but also the final number of caps. In most cases a higher auxin-level was needed for the optimum effect in enucleated than in intact plants.

Additional evidence is supplied by the finding that triiodobenzoic acid, 10^{-4} *M*, inhibits strongly the formation of caps by enucleated plants. It can be concluded that both auxin and an auxin antagonist are able to act on the cytoplasm. Whether or not the nucleus makes the action more effective must be left open.

In general, our experiments indicate that auxin plays a growth-promoting part, rather than being itself one of the previously postulated morphogenetic substances. Since it does not increase cap formation when applied to old plants which have already begun to form caps, it cannot be the cap-forming substance itself. It cannot be the precursor which is converted to cap-forming substance by bright light[19,20], because if so it should always (in optimum concentration) produce 100 per cent caps in bright light. For the same reason it can scarcely be any earlier intermediate in the chain. Therefore it must act only to promote one or more of the reactions leading to cap formation. This role is comparable with the influence of externally applied auxin on elongation in *Acetabularia*, which is also only a promotion. The part played by endogenous auxin in these reactions will be a subject for further study. In the meantime, the fact that these effects can occur, albeit to a limited extent, in the absence of the nucleus, seems to us of importance for theories of auxin action.

This research was carried out during the tenure of a Guggenheim Fellowship by one of us (K. V. T.). Use of the facilities of the Naples Marine Station, and the helpful co-operation of the director, Dr. R. Dohrn, and his staff are gratefully acknowledged.

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LETTERS TO THE EDITORS

BIOLOGY

Fluorescence Effects from Corals irradiated with Ultra-Violet Rays

In January 1957, three months after the official inauguration of the Aquarium of Nouméa which my wife and I established in New Caledonia, we obtained the first effects of fluorescence through irradiation with ultra-violet rays of deep-water corals. The different specimens treated had been collected in the lagoon at a depth of 35–40 m., about twenty miles from our station where they are kept alive.

The first corals on which we experimented belonged mainly to the genus *Flabellum*, with which we obtained green fluorescence of great intensity. (There is no doubt that it is fluorescence, as the phenomena stop as soon as the excitation ceases. In other words, there is in these corals no residual photoluminescence, which becomes apparent as soon as the irradiation ends.) Since then, all specimens of corals, collected in the same region and elsewhere from varying depths, have been systematically exposed to treatment with ultra-violet radiation.

Our preliminary observations are as follows: (1) Only a certain number of species respond to irradiation. (2) All individuals belonging to the same genus produce generally the same colour of fluorescence (thus the *Flabellum* show greens, the *Trachyphyllia* oranges, etc.). However, certain genera may present several colours in the same individual. In that case a particular colour is always localized in the same region on each organism. (3) Colours and frequency-range are, at present: green, varying from light to dark, and at times with a glow; orange, varying from light to dark and at times with a brilliant glow; silver blue (very small range); reddish (either dull or shiny); beige (very small range); brown (very small range); and grey (sometimes silvery).

The definite green colour of certain corals may sometimes change to pink either after frequent or too lengthy exposures to irradiation or perhaps from other causes. (4) Only the fleshy parts of corals are fluorescent; the skeleton itself never reacts. (5) The expansion of polyps of certain species, especially those which expand normally in day-time, is greatly excited by ultra-violet irradiation, while species which expand at night do not react positively. (6) Most corals exposed to ultra-violet irradiation suffer from this treatment. In certain cases it may be fatal if the experiment is repeated too often or if it is of too long duration. Generally speaking, the intensity of fluorescence decreases day after day in proportion with the decreased vitality of the subject treated.

Other organisms collected from a depth of 35–40 m., particularly anemones and calcareous algae, show fluorescence, but its intensity is much less than that observed with corals.

Apart from the exceptional beauty of the fluorescent corals, the phenomena suggest research in different fields such as chemistry, physics and biology. Finally, this fluorescence might be a new approach to the systematic study of these corals. In fact, certain specimens which seem *a priori* to belong to the same species react to ultra-violet irradiation with quite different colours.

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Lumpy Skin Disease of Cattle in Kenya

Lumpy skin is an infectious disease of cattle characterized by the eruption of cutaneous nodules on any part of the body together with generalized lymphadenitis. It has been known for some time in several African territories, including Northern Rhodesia (1929)[1,2], Bechuanaland (1943)[3], the Union of South Africa (1944)[4], Southern Rhodesia (1945)[5], Mozambique (1946)[6], Swaziland (1946)[7], Basutoland (1947)[7], Madagascar (1954)[8] and Belgian Congo (1955)[9]. The dates of first confirmation in these countries are in parentheses.

To the above list must now be added Kenya, where the disease was recognized for the first time towards the end of 1957 on a farm in the Nakuru area. The source of infection in this outbreak is unknown. The disease was confined to calves, some of which were severely affected. The natural mortality was very low, and all active cases were slaughtered. After confirmation of the initial outbreak, field staff of the Veterinary Department carried out an extensive and systematic search for further cases of the disease over a wide area of the surrounding districts. Only a few active cases were found on widely separated farms. These were generally mild in character, and involved, as a rule, only one or two animals in each herd. Over the past year lumpy skin disease has spread slowly and sporadically despite the enforcement of stringent quarantine restrictions and sanitary arrangements. Cattle on recently affected farms in the vicinity of Lakes Nakuru and Elmenteita, however, have shown a higher morbidity, and individual cases have been more severe.

In Kenya, as in other affected territories, the spread of the disease has been unaccountable. Outbreaks have occurred in herds several miles apart with no evidence of infection on neighbouring or intervening farms. There was severe infestation by mosquitoes on the first farm where the disease was diagnosed. Infestations of varying severity have also been reported on 54 out of 56 farms afterwards infected by lumpy skin disease. The possible role of mosquitoes as vectors of the disease is under investigation.

In the more severe cases in Kenya nodules have been found not only in the skin but also in the internal organs, for example, oral cavity, pharynx, larynx, trachea, lungs, liver and proventriculi. Histological examination of skin and other lesions has revealed the presence of intracytoplasmic inclusions in a large proportion of cases in the epithelial and infiltrating mononuclear cells similar to those first described by Thomas and Mare[4].

Alexander *et al.*[10] have isolated three types of infective agents from cases of lumpy skin disease. One of these, their group II, produces a generalized

response on the part of susceptible animals with the development of nodules over practically the entire body following subcutaneous inoculation of virus. In tissue-culture monolayers this agent gives rise to the rapid formation of large syncytia and the development of large intranuclear inclusions. Agents of this type have not, so far, been isolated in Kenya. Another type of agent, group III, rarely produces generalized skin eruptions on inoculation of susceptible cattle. In tissue culture the cytopathic changes develop more slowly than those of the first type and the inclusions are intracytoplasmic. Seven separate isolations of agents of this type have been made so far in this Laboratory from different farms, including the farm originally infected.

In addition there have been five isolations of a type of agent from active cases of the disease which gives rise to characteristic cytopathogenic changes in cell cultures but which elicits no clinical response whatsoever on inoculation of susceptible cattle. In this respect these resemble the agents of Group I as described by Alexander *et al.*[10].

Fuller details of the work carried out so far on lumpy skin disease in this Laboratory will be reported shortly.

We are grateful to the Director of Veterinary Services for permission to publish this preliminary communication.

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Dec. 23.

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Records of Young Eels in Kenya Rivers

Frost[1] published the first account of the biology of freshwater eels in Kenya. She showed that, of the three species of eel found in the easterly flowing rivers, *Anguilla nebulosa labiata* Peters is the most abundant above 3,000 ft.; *A. mossambica* Peters is comparatively rare, and *A. bicolor bicolor* McClelland is both uncommon and apparently restricted to the lower reaches of rivers. Our own (unpublished) records from the lower Sabaki (Athi) River and from upper tributaries of the Tana River confirm this distribution.

The elvers of *A. mossambica*, the common South African eel, are now well known, and runs up the Buffalo River (Eastern Cape) in February and March have been recorded for three successive years[2-4]. Recently, the elvers of *A. b. bicolor*, known previously only from Madagascar, were found at sea-level in the Mzinga River near Dar es Salaam (Tanganyika) in late January and mid-February[5]. With these elvers were two which could be referred to *A. n. labiata*, the first to be recorded. But apart from two rather damaged early stages (165 and 115 mm.) collected by Frost[1], the largest of which she tentatively assigned to *A. n. labiata*, there have been no records of elvers or young eels in Kenya rivers.

Table 1

Source	No. of specimens	Total length (mm.)	Ano-dorsal fin ratio		Vertebral count†
			Elvers	Adults*	
A. Merilla Barrage (Tana River) April 24, 1958	18	104–161	9·7–13·4	10·0–14·9 (*A. n. labiata*)	105–108
B. Jilore (Sabaki River) Nov. 1956	1	87·5	11·4	14·6 (*A. mossambica*)	91

* Based on Frost's Kenya collection (unpublished).
† Counts determined in *A* by dissection (one) and by X-ray photographs (five); in *B* by X-ray only.

In June 1957 we received reports of numerous 'elvers' having been found among the debris caught up in the draft tubes of the turbines at the Tana Hydro-electric Power Station on the Tana River, at an altitude of approximately 3,800 ft. (0° 40′ S.; 37° 14′ E.). Unfortunately no specimens were kept. However, further investigation in the vicinity of the power station in April 1958 produced eighteen young stages of eels which had been trapped in the syphon-priming chamber of the dam serving this power station (the Merilla Barrage), the construction of which device enables it to function as a very efficient elver trap. Subsequent visits have proved negative, but more young stages are expected in the appropriate season, which is probably during the 'long rain' floods of March–May in this area. The total lengths of the young eels (104–161 mm.) are considerably larger than the lengths of elvers recorded by Frost[5] at sea-level, suggesting that they are in fact post-elvers. Although apparently caught while migrating upstream, there is no indication of their date of arrival at the Tana River mouth, some 300 miles to the east, and it is also possible that they had remained in the priming chamber for some time. We have also been able to examine a much smaller eel (87·5 mm.) caught in a native basket-trap at Jilore on the Sabaki River (3° 8′ S., 40° 4′ E.) by Mr. John Kadenge, this locality being only 20 miles from the sea at an altitude of 100 ft. There is some doubt regarding date of capture, but it is believed to have been trapped during the 'short rain' floods of November 1956.

Adults of the three Kenya species of eel can be separated on the basis of dentition, coloration, the ano-dorsal fin origin formula used by Frost[1], and vertebral counts. These characters are not entirely satisfactory for the young stages, although vertebral counts are probably the most reliable.

Coloration. The eighteen Tana River eels were distinctly mottled, as are the adults of *A. n. labiata*, but after preservation in formalin or alcohol only the largest retained this coloration. The single Sabaki River elver, first inspected after about 18 months in formalin, showed a light peppering of chromatophores above the mid-lateral line, but no suggestion of mottling.

Dentition. As in adult *A. n. labiata*, the largest Tana River eels appear to have a slight groove between the lateral rows of teeth in both jaws, but in the smaller specimens and in the Sabaki River elver the teeth are rather irregularly placed.

(*Continued on p.* 971)

Supplement to NATURE

No. 4666 APRIL 4, 1959 Vol. 183

FROM DAN TO BEERSHEBA: EXCAVATIONS IN NORTH AND SOUTH PALESTINE

Lachish (Tell ed-Duweir) IV

The Bronze Age. By Olga Tufnell. With contributions by D. F. W. Baden-Powell, Dorothea M. A. Bate, Jaroslav Černý, David Diringer, Madeleine Giles, Hans Helbaek, B. S. J. Isserlin, Margaret A. Murray, Barbara Parker, Edith Porada, F. C. Thompson, Eric Todd and John Waechter. Text: Pp. 351. Plates: pp. 6+96 plates. (The Wellcome-Marston Archæological Research Expedition to the Near East.) (London: Oxford University Press, 1958. Published for the Trustees of the late Sir Henry Wellcome.) 168*s*. net (text and plates).

Hazor I

An Account of the First Season of Excavations, 1955. By Yigael Yadin, Yohanan Aharoni, Ruth Amiran, Trude Dothan, Immanuel Dunayevsky and Jean Perrot. (The James A. De Rothschild Expedition at Hazor.) Pp. xxiv+160+184 plates. (Jerusalem: At the Magnes Press of the Hebrew University; London: Oxford University Press, 1958.) 168*s*. net.

THE appearance of Lachish IV brings to a close the immense task of publishing the results of six seasons of excavations at Tell ed-Duweir in southern Judea, and Miss O. Tufnell and her collaborators are to be warmly congratulated on their achievement. The excavations themselves ended in 1938 with the tragic death of their director, J. L. Starkey, and since then it has been the task chiefly of Miss Tufnell to gather together the records of the work and present them to the public. Previous volumes have given accounts of the Biblical city, the Canaanite temple, and of important epigraphic material. The present volumes trace the history of the *tell* itself and the neighbouring cemeteries from the Chalcolithic period until the destruction of the city by Israelites or Philistines about 1200 B.C. Although the only important structure described is the Middle Bronze Age glacis defence system, a wealth of material from the Early, Middle and Late Bronze Ages is carefully analysed, and an outstanding contribution is made to our knowledge of south Judean civilization during the third and second millennia B.C.

The most interesting sections deal with what Miss Tufnell calls the 'Caliciform culture' (Albright's Middle Bronze I, and Miss Kenyon's Intermediate Early–Middle Bronze). Miss Tufnell prefers to see in the differences between various groups of Caliciform pottery evidence for a chronological succession, rather than for different ethnic groups, as Miss Kenyon has suggested at Jericho. If the "straggling house walls" of the north-west settlement (p. 42) really belong to this period, then their plan (Plate 95) lends support to this theory, since they obviously belong to several superimposed building phases. It is a pity that these phases are not noted or analysed in the report.

It is not to be expected that this is an ideal publication. An interval of twenty years between excavation and report is too long, and Miss Tufnell has had to cope with another archæologist's records, which were, plainly enough, in many cases inadequate. The treatment of the north-east section, for example, is very sketchy, as is the drawing of the section itself, and consequently the discussion of the development of pottery types lacks that close stratigraphic control which is essential. In this respect the charts (Figs. 2–5) are especially suspect; sherd No. 123, for example (Fig. 3), from the 22-ft. level of the Middle Bronze glacis fill, looks very like a Chalcolithic bowl-rim. So, too, the references to the earliest material from Duweir—a Natufian end-scraper, a Neolithic painted sherd, and a grooved stone of Mesolithic/Neolithic type—are tantalizingly brief. There is enough evidence here to suggest that at the base of the mound the remains of a Neolithic community still lie buried.

The weakest point of the Lachish report lies in its arrangement. The student looking up comparative material is sent from page to page by a confusing series of cross-references and repetitions. Thus, there is a partial discussion of the Caliciform culture on p. 31 and a second, with new remarks, on p. 41; while the important group 1529 is treated on both p. 42 and p. 171 ff., and other groups of the same period on p. 153 ff. Similarly, on pp. 132–33 Prof. Černý reports on the Egyptian hieratic inscription on Lachish bowl III, while another opinion by Sir Alan Gardiner is quoted on p. 37. This leads to confusion and unnecessary labour.

Nevertheless, Miss Tufnell deserves great praise for publishing the material and records, however scanty, of this excavation. For many years to come these volumes will be one of the most important sources for the archæological history of Palestine. Their format is of the usual high standard of the Oxford University Press. I would make only one criticism: the form "ist", "iind", etc., for "1st", "2nd", is, to my mind, extremely ugly.

Tell el-Qedah is by far the largest (185 acres) ancient site in Palestine, and guards the main northern cross-roads in the Huleh plain. Its importance as the centre of Canaanite civilization in the north can be gauged from the number of times it is mentioned in Egyptian, cuneiform and Hebrew texts, and Dr. Y. Yadin and his army of assistants have now uncovered an impressive amount of the remains of this civilization, together with equally important remains of the Israelite period. Deserving of special mention are the pillared building of the time of Omri and Ahab

(ninth century B.C.), the eighth century citadel, and the Late Bronze Age shrine, which, with its steles and cult-objects, throws a flood of light on Canaanite art and religion.

The wealth of archæological material found is here superbly presented, and this attractive volume is a credit to the Israeli printers and publishers responsible for it. I doubt, however, whether it is altogether wise to publish on so lavish a scale the results of the first of a series of excavation seasons. Dr. Yadin is himself aware of the drawbacks (p. xix), but considers them to be outweighed by the advantages of prompt publication. One cannot help feeling, however, that most of the important material could have been published in a series of more modest preliminary reports, leaving the final discussion of the major structural remains to a later date. An excavator's appreciation of the significance of his discoveries and of the history of his site must continually change with every new find. Even in Hazor I the evidence of later seasons is incorporated into the discussion at several points, for example, in the case of the Late Bronze Age shrine, while, conversely, the analysis of certain strata is left incomplete, to be discussed in a future volume. Promptness in publication is an admirable aim, but not if it means unnecessary duplication, especially when volumes are 8 guineas each.

Dr. Yadin's method of elucidating the history of Hazor has been to divide up his excavated areas vertically into a number of strata, each containing a complex of contemporary buildings. The criteria for establishing contemporaneity seem to be the plans of the buildings and the absolute levels of their floors. The strata are dated by the objects found therein. This method has undoubtedly established the broad outlines of the chronology of Hazor; but the treatment is really not as detailed as it could have been. Within any one stratum there are bound to be a number of sub-phases, which here usually pass unremarked. For example, the plan of area *A*, stratum VI (Plate CLXXIII) suggests that locus 76 was originally an open space between two buildings, and that the northern wall is a later addition. The exact sequence in this area could only have been ascertained by a much closer observation of the stratigraphy than the published report indicates. Again, it is axiomatic that all the material from one 'stratum' is not of equal value for the dating of that stratum. The pottery lying on the floor of a house will date from the last period of its occupation; the pottery from the deposit between one house and another above it may, according to whether that deposit is a destruction debris or a deliberate filling, either date the destruction of the lower house or the construction of the upper; while the latest sherds from the foundation trenches of a building will usually date its construction. Very seldom, if at all, are foundation trenches mentioned in this report. Pottery is said to come from a given locus, which is sometimes described as a room, a wall, a floor, etc.—sometimes, even, as 'undefined'—while the important fact, whether it comes from occupation material, debris, a deliberate filling, etc., is rarely stated. A curious instance of this failure to appreciate the significance of the exact provenance of finds occurs in the discussion of shrine 1*A*, in area *C*. On p. 91 it is stated that a Cypriot milk-bowl of White Slip II type is one of the most significant sherds for dating the shrine. This bowl comes from locus 6062, which the plan (Plate CLXXX) shows to be a spread of small stones overlying wall 6134, the west wall of the shrine; this wall seems to have been destroyed at this point (it is shown only in broken lines on the plan, Plate CLXXXI). This stony spread is, according to the absolute levels printed on the plan, about 30 cm. above the top of wall 6134, and is surely one of the "several layers of small rubble stones" which on p. 75 are said to cover the slopes of the earthen rampart, west of the shrine, and to be either an intentional revetment or debris from houses above. In either case, this milk-bowl, and the sixteen other sherds published from the same locus, can scarcely be used as dating evidence for shrine 1*A*.

Despite this lack of precision in the analysis of the stratigraphy of the site, this volume is most welcome as providing a yardstick for future work in Palestine. The drawings and the plans are excellent; especially is one grateful for the generous folders on which the plans are printed. The photographs are not so good. Too many of them have been taken in strong sunlight, which produces confusing shadows (for example, Plate VI, No. 6), while illustrations of objects *in situ* are of little use if, as is often the case here, the *situs* is not readily discernible in the picture. Fewer, better, photographs might have helped to reduce the cost of this report.

PETER J. PARR

"ARMS AND THE MAN"

No More War

By Dr. Linus Pauling. Pp. x+254. (London: Victor Gollancz, Ltd., 1958.) 16*s*. net.

The Devil's Repertoire or Nuclear Bombing and the Life of Man

By Victor Gollancz. Pp. 192+2 plates. (London: Victor Gollancz, Ltd., 1958.) 10*s*. 6*d*., cloth bound; 5*s*. paper covers.

The Arms Race

A Programme for World Disarmament. By Philip Noel-Baker. Pp. xviii+579. (London: Atlantic Book Publishing Co., Ltd., 1958. Distributed by Stevens and Sons, Ltd.) 25*s*. net.

THESE three books are essentially variants on the thesis that the advent of the nuclear bomb has made the renunciation of war inevitable if mankind, let alone civilization, is to survive. The thesis is stated succinctly by Dr. L. Pauling in his preface, but the level of that preface is scarcely sustained, and even the scientist may find Dr. Pauling's the least satisfactory book of the three. It is indeed addressed to the non-scientist and successive chapters explain in non-technical terms for the general reader the nature of nuclear weapons, what is meant by radioactivity and fall-out, the relations between radiation, heredity and disease. The facts about fall-out are summarized in a separate chapter, which, while not attempting to conceal the incompleteness and contradictions in existing knowledge, strongly supports the recommendation of the Committee on the Biological Effect of Atomic Radiation set up by the U.S. National Academy of Sciences—National Research Council that exposure to radiation should be kept as low as possible. After explaining, in a chapter on the nature of nuclear war, the reasons for his fear that such a war would mean the end of civilization, Dr. Pauling surveys in the following two chapters the several appeals for peace made by

scientists and the need for international agreement. Finally, he outlines his own proposal, namely, research for peace.

He suggests that a World Peace Research Organization should be set up within the United Nations to study how to solve great world problems of the kind that have in the past led to war, including an attack on the problem of preventing the outbreak of a nuclear war by design or by accident. Dr. Pauling visualizes such an organization, after a thorough analysis of the problems involved in an international agreement to stop all testing of nuclear weapons, formulating a system offering the maximum safety and the least risk of violation, and he is prepared to place at the disposal of the organization a staff of some 2,000 specialists within two years, a figure which might rise to 10,000 within a decade, and puts the cost of the proposal as initially some 25 million dollars a year and ultimately 100 million dollars. He argues that if world problems were attacked in this way, imaginatively and with original methods by outstandingly able investigators, there are great possibilities of progress and of discoveries which would make the outbreak of a nuclear war far less likely. Except in its scale the proposal is scarcely novel, as the work of the Institute of Pacific Relations has shown for a quarter of a century.

Dr. Pauling is convinced that such an organization would repay its cost in savings in defence budgets and in other ways, and points out that the sum he contemplates is only a small fraction of the military budget of even one country such as the United States or the U.S.S.R. He does not, however, quite meet the point of urgency that is one of the critical aspects of the situation, nor what is implied in the diversion of such a proportion of the world's limited resources in highly varied scientific man-power to this constructive purpose. If the nations were prepared to take that immediate step, may not some more direct action in regard to disarmament be possible now?

The interest of the book to the scientist lies largely in these last chapters and, while its bibliographical references are rather scanty, it reproduces the *Mainau Declaration of Nobel Laureates of July 1955*, Schweitzer's declaration of April 1957, and a statement of Einstein's which are convenient for reference. Dr. Pauling does not, of course, ignore the moral aspect, and he argues in conclusion that the use of nuclear weapons is immoral and that morality must now take its proper place in the conduct of world affairs. This, however, is the essence of Mr. Gollancz's book, which presents persuasively, sensitively and with real felicity and sincerity the spiritual and moral issues involved, taking the thesis one step further to argue for unilateral nuclear disarmament. Mr. Gollancz does not shrink from what might be involved in such a step, but no more than Dr. Pauling does he really face some of the real practical difficulties or the moral issue of involving others in the consequences of a unilateral decision.

In this respect, the major contribution comes from Mr. Philip Noel-Baker. Much the longest of the three, his book considers nuclear disarmament as a facet of general disarmament and in the light of the experience gained in the long negotiations for disarmament under the League of Nations. Mr. Noel-Baker is convinced that much of that work is relevant to present problems, and without disguising the need for anxiety and urgent action he takes a hopeful view of the possibilities. The scientist will find much of interest in this lucid, well-documented and authoritative survey; not least, a compelling demonstration of the futility of military or defence research. The argument is realistic, without ignoring or despising the moral argument, and although it does no more than outline the broad stages by which disarmament should proceed, it calls just as incisively as Dr. Pauling for bold and large steps, including the abolition of military research, and for the patient and determined pursuit over many years of new policies and reforms based on known facts, which the recently established Institute of Strategic Studies could well help to disseminate. R. BRIGHTMAN

MODERN MIND

The Emergence of the Modern Mind
Edited by Prof. Frederick C. Gruber. (The Martin G. Brumbaugh Lectures in Education.) Pp. 93. (Philadelphia: University of Pennsylvania Press; London: Oxford University Press, 1958.) 20*s*. net.

THIS book consists of the four Martin G. Brumbaugh lectures given at the University of Pennsylvania in 1957. They are popular lectures, designed mainly for students of education. Prof. Conway Zirkle, writing on "Our Biological Inheritance", paints a lively but gloomy picture of man as the most successful of animals, yet ill-adapted to the cultures he has produced; knowledge has grown too big for us, our work is dull, civilization is a strain from which the human animal sometimes seeks violent escape; perhaps hope is possible when we look back in history and see what catastrophes we have survived or consider what further successful adaptations we may achieve in the next half million years; we may even survive some of our present world-views. Prof. Edel, on "The Greek Image in American Thought", emphasizes the freshness of Greek thought for Western civilization and our need to look back to the Greeks for new ideas. He is scornful of those bolstering up reactionary philosophies by skilful quotation from Plato. The Greeks must be approached in their own spirit of free inquiry; the questions they discussed are the ones we find important; as an example Edel gives a skilful analysis of the underlying assumptions of democracy, looked at in the light of Plato's "Republic".

The other two lectures are less interesting. Prof. Ethel Alpenfels's essay on "The Mind and the Mores", is very slight; she applies the social anthropologist's view of culture to American 'folkways and mores'; but she never makes it clear how far human beings are 'determined' by their cultures and how far they are free individuals capable of independent thought. Prof. Percy Miller's picture of "Nineteenth Century New England and its Descendants" would be of more interest to Americans than to Britons; his references are too off-hand for us to judge the relevance of his criticisms; and although he wants to show us the greatness of Henry Thoreau, he does not tell us enough about his life, work and writings to convince.

It will be noticed that the link between these essays and the title of the book is tenuous, but this is not important. Although there is nothing original in these lectures and the writing is sometimes pretentious or naïve, they are on important topics and would have a stimulating effect if used, for example, in the sixth forms of grammar schools as a basis for discussion. T. H. B. HOLLINS

NEUROPHYSIOLOGY OF BEHAVIOUR

Ciba Foundation Symposium on the Neurological Basis of Behaviour

Edited by G. E. W. Wolstenholme and Cecilia M. O'Connor. (In commemoration of Sir Charles Sherrington, O.M., G.B.E., F.R.S., 1857–1952.) Pp. xii+400. (London: J. and A. Churchill, Ltd., 1958.) 52*s*. 6*d*. net.

THIS volume contains a collection of some nineteen papers presented at a Ciba symposium commemorating the birth of Sir Charles Sherrington in 1857. As is usual with Ciba symposia, the meeting was attended by only a small international group, and the book is intended to present the proceedings to a much wider circle. The papers covered many fields related to neurology, but the main emphasis was, as might be expected, on neurophysiology and experimental neurology.

The latest data on the activity of single neurones of the spinal cord are reviewed by Eccles, while the behavioural effects of lesions (Bard, Brierley, Kluver) and electrical stimulation, both in animals (Olds, Andersson, Monnier) and in man (Penfield) are very adequately covered. Other fields discussed are: sexual behaviour (Harris), the effects of stress (C. P. Richter), the rhinencephalon (Green), brain enzymes (Rosenzweig) and drug action (Elkes). Many of the papers are reviews containing material much of which has already been published; nevertheless they serve to bring this together for discussion, which follows each paper. On the other hand certain papers contain a proportion of new information, and these, while they illustrate trends in research, also focus attention on the fact that new developments in this field must depend upon advances in technique. For example, Olds outlines the new results which are coming from experiments on electrical self-stimulation in animals; Jasper reviews the responses of single cortical neurones in unanæsthetized animals during conditioning; and Malcolm discusses the activity of cortical neurones in freely moving animals. All these developments and many others which are providing information linking electrophysiological and behavioural studies depend upon new technical skills.

The only criticism which one might make is that the contributions made by psychology and biochemistry to this symposium are small, yet both these fields of study are becoming increasingly important to work on neurological mechanisms. However, no symposium can ever be truly comprehensive if it is to be confined to a single volume at a reasonable price, and this book provides an excellent review of our present state of knowledge in this subject. It is well illustrated and contains an adequate index.

P. B. Bradley

PHYSIOLOGY OF THE CEREBELLUM

The Physiology and Pathology of the Cerebellum

By Prof. Robert Stone Dow and Prof. Giuseppe Moruzzi. Pp. xv+675. (Minneapolis, Minn.: University of Minnesota Press; London: Oxford University Press, 1958.) 100*s*. net.

STUDENTS of cerebellar physiology have been well served by a sequence of splendid critical writings, each marking a distinct advance in knowledge, and in some degree defining the direction of later research. Foremost among them stand those of Sherrington (1900), Luciani (1915), Bremer (1935) and Holmes (1939). Dow and Moruzzi's new book will take its place with these. A physiological and pathological study of the cerebellum, it is planned as companion to a forthcoming morphological treatise by Larsell.

In their general nature, and in the technical approach to them, cerebellar problems resemble those presented by other parts of the central nervous system, but without preoccupation with the relation between nervous and mental events. The oldest approach tries to analyse the disorder of function—in this case, of posture and movement—resulting from destruction of the cerebellum or of some part or parts of it. Following the injury, the pattern of disability undergoes progressive change until a final steady state is reached. It is difficult to determine how far the disability at each stage is 'negative', due to lack of cerebellum, and how far 'positive', due to new activity of surviving nervous tissue. The general conclusion, however, is that the cerebellum tends to subdue postural reflexes on one hand, and on the other, to reinforce and steady the motor outflow from the brain. Electrical stimulation, although its effect is mixed, confirms the reality of these two streams of action.

The large and richly folded cerebellar cortex (with an area only a small fraction of which is exposed on the surface of the organ) receives impulses from all the receptors, and not only from the proprioceptors, as would have been expected from pioneer work. These impulses arrive at areas the surface localization of which is sharpest in deep anæsthesia. The cortical Purkinje cells send impulses to the cerebellar nuclei and thence to brain and cord. How far is this cortical output directly driven by the afferent input, and how far by intrinsic neuronal activity of the cortex? This cortex has the same apparently homogeneous, but very complex, microscopical structure throughout its extent. In the past there has been some loose usage of the term 'functional localization'. Anatomical localization of areas of arrival and departure of impulses has been abundantly shown. Is the active response of the cerebellar cortex to incoming impulses also localized, or is there, rather, spread and mass action, converging ultimately upon the different corticofugal systems?

On these and many other questions, this book assembles a wealth of experimental and clinical fact. The bibliography has about 2,000 references, old as well as new, and in many languages. These are not merely quoted, but critically appraised: the authors have taken great trouble to extract from them the facts needed for reasoning, and to reject poor observations (for example, those with inadequate anatomical control). The arrangement is methodological: ablation experiments; stimulation experiments; electrophysiological experiments; the cerebellum and other central structures; clinical symptoms; pathology. The analysis of clinical symptoms reveals the full stature of Gordon Holmes's contribution to cerebellar physiology. The pathological processes affecting the cerebellum are admirably described from the physician's point of view. Some of the sections end with interesting general essays, and these, and the essay "General Considerations on the Function of the Cerebellum", might well be read consecutively. The book as a whole would probably not be read consecutively by anyone other than a reviewer; but it is all very readable, well indexed

and well supplied with cross-references. Its great virtue is that it proclaims the important matters on which we are ignorant, and does not somehow convey the idea, as other writers on the nervous system, no doubt unintentionally, have sometimes done, that our understanding is all but complete. By this frankness it hopes, and is likely, to stimulate research. It is the fruit of more than twenty years practical work, thought and reading by both authors. It could not possibly be mistaken for a mere journalistic compilation.

C. G. PHILLIPS

CLINICAL AND EXPERIMENTAL CANCER RESEARCH

Carcinoma of the Lung

Edited by J. R. Bignall. (Monographs on Neoplastic Disease at Various Sites, Vol. 1.) Pp. xii+298. (Edinburgh and London: E. and S. Livingstone, Ltd., 1958.) 55*s*. net.

Variables Related to Human Breast Cancer

By A. Elving Anderson, Harold O. Goodman and Sheldon C. Reed. (A Study from the Dight Institute of Human Genetics.) Pp. xiii+172. (Minneapolis, Minn.: University of Minnesota Press; London: Oxford University Press, 1958.) 32*s*. net.

Proceedings of the Second International Symposium on Mammary Cancer

Held at the University of Perugia, 24th to 29th July, 1957. Edited by Lucio Severi. Pp. liv+871. (Perugia: Division of Cancer Research, 1958.) 12,000 lire; 145*s*.; 20 dollars.

THREE recent books illustrate a current trend towards the detailed study of neoplasia in particular organs or tissues in human beings as well as in animals. Carcinoma of the lung is the subject of the first of a series of monographs designed to cover the range of neoplastic disease in special sites. The series is based primarily on the first-hand clinical experience of a group of postgraduate teaching hospitals in London supplemented by expert aid from other sources. The present volume, reflecting the practice of the Royal Marsden and Brompton Hospitals, includes a discussion of etiology, occupying about one quarter of the whole, by R. Doll. Dr. Doll expounds his views on the etiological importance of cigarette-smoking lucidly and persuasively. The weakest link in the argument seems to be the identification of the mechanism of carcinogenesis; the evidence for decisive operation of carcinogenic hydrocarbons is unconvincing. The main thesis rests on information about what actually happens in human beings, and although Dr. Doll is convinced by the evidence incriminating cigarette-smoking, he recognizes that inconsistencies persist and that interpretation is difficult.

The intrinsic hazards in the study of the etiology of human neoplasia are well shown in a report from Minnesota of a careful and critical investigation of the role of genetic factors in cancer of the human breast. The authors give especial attention to the validity of research methods; many previous investigations are clearly inadequate. Their own conclusions are cautious. They find good evidence that mothers, sisters and daughters of breast-cancer patients are about twice as liable to cancer of the breast as other women of similar age, and that the enhanced liability does not apply to cancer at other sites. Genetic factors are probably involved in the etiology of human breast cancer but are less important than non-genetic factors. These investigators are not satisfied that information now available about such factors as marital status, number of pregnancies and breast-feeding is sufficient to justify the advocacy of prophylactic measures, and they show a welcome recognition of the danger of meddling with the lives of human beings on the basis of imperfect and incomplete understanding of neoplastic processes in the breast.

The limitations of knowledge are also evident in the report of the Second International Symposium on Mammary Cancer held in Perugia in 1957. More than eighty contributions from fifteen countries cover a wide range of observations and opinions, human and animal studies being about equally represented. The endocrine aspects of mammary cancer receive most attention. Although there is wide agreement among the contributors that hormones are important in the etiology of cancer of the human breast, the mechanism of their action is not known. Moreover, the endocrine management of advanced breast cancer remains almost wholly empirical. These matters call for the closer integration of clinical and experimental research which this valuable symposium was designed to encourage; the clinical and experimental approaches are complementary and not alternative or competitive. The report scarcely does justice to the value of a symposium that brought clinical and laboratory workers together for informal discussions as well as formal expositions, but it is welcome, nevertheless, as a record of current thought and research on mammary neoplasia. All three books may be commended as valuable contributions in their several ways to the study of a subject of great complexity.

L. FOULDS

MECHANISM OR VITALISM?

The Physical Foundation of Biology

An Analytical Study. By Prof. Walter M. Elsasser. Pp. x+219. (London and New York: Pergamon Press, 1958.) 30*s*. net.

THE conflict between mechanistic and vitalistic philosophies has never quite subsided. Biologists, who on the whole have a profound respect for the senior physical sciences, tend to hold mechanistic views, at least as a working hypothesis, while physicists, knowing rather more of the limitations of their own discipline, are more inclined to assign special properties to living organisms. Prof. W. M. Elsasser, whose professional domain is magneto-hydrodynamics, has taken great pains to survey those phenomena displayed by living creatures which can be described in mechanistic terms, so as to identify the residue of functions which, he asserts, cannot be effected by physical means. For phenomena in this class, which cannot be interpreted in terms of pure mechanism, he proposes the term 'biotonic', which he defines as "Any causal relationship which involves an increase of information content in the system with the passage of time". The most prominent member of this class, he suggests, is organic growth of information, and he tries to show that neither genetic nor cerebral information can conceivably be "stored" in a physical sense, because of the minute scale of the structures involved—the chromosomes of the gametes or the nerve tissue of the brain. In an artificial computing machine there may

be several grades of storage register, giving different degrees of capacity, accessibility and permanence, each fulfilling particular functions, and exploiting various physical effects such as ultrasonic vibration, electrostatic induction, and magnetic induction, apart from the familiar records in printed or punched cards. The total information storage capacity of a large computer may be quite imposing but does not approach the order of information contained in a human organism which, Elsasser suggests, may be as high as a thousand million bits. If a storage register of this capacity were required, the physical size of the storage system would have to be reduced, and a point would be reached at which the random variations of the system, the Brownian movement, or noise-level, would be of the same order as the magnitude of the stored signals. In such conditions, so the argument runs, the inevitable loss of information or ambiguity can be made good only by redundancy in the form of repetition or reduplication, which requires still more storage space, and so on. The conclusion reached is that no mechanical storage system can be imagined, still less constructed, which would contain enough information to specify the development or the mentality of a human organism. In the special case of human memory a particular difficulty, according to Elsasser, is that "There is no anatomical evidence for a storage organ", and also, "brain physiology has not brought to light any evidence for . . . special scanning devices" which, according to engineering principles, are needed for the selection and distribution of large stores of information.

Thus, proceeding from the Bergsonian idea that "the deviation of organisms from mechanistic behaviour ought to be studied in terms of the failure of information storage", this eminent and scholarly physicist develops a logical and consistent argument in support of the notion of epigenesis, claiming that the existence of biotonic laws is justified by the principle of finite classes which prohibits logical decisions involving operations in immense classes.

The argument is not easy to follow, and the reader's confidence is strained by the intrusion of several errors and oversights, particularly in the sections on neurophysiological data; neither the velocities nor the durations of nerve impulses are limited to the ranges quoted, and their strict relation to impulse wave-length should have directed the author's attention to the logical inconsistency in this paragraph. There is in fact some evidence of a scanning or space-time transforming mechanism within the brain, as well as of considerable redundancy in both genetic and cerebral structures. Not all matings are fertile, and many have monstrous issue ; by no means all memories are true, many are redundant and all are fragile.

In spite of the author's reasonable doubts, the storage capacity of a statistically assembled system of ten thousand million elements is not easy to estimate, and it may well be that in free permutative combination the figure would be of the required order. The same consideration applies to the inter-connexion of radicals in the nucleo-protein systems of chromosomes ; our present lack of complete factual knowledge does not seem to justify a philosophical denial of the possibility.

In a book of this size and scope, a subject index would have helped to restore biotonic energy, but there is an excellent summary in a few pages.

W. Grey Walter

BIOLOGICAL ULTRASTRUCTURE

Biological Ultrastructure

By Arne Engström and J. B. Finean. Pp. ix+326. (New York : Academic Press, Inc., 1958.) 8 dollars.

THE appearance of a new book in this rapidly developing field is greatly to be welcomed. During the past ten or so years an extraordinarily high degree of success has attended the application of various biophysical techniques and ideas to the study of molecular biology, and the time is certainly ripe for these developments to be recounted in generally accessible form. In the work under review, Prof. Engström and Dr. Finean have gone a considerable way towards doing this. The book commences with a section on "Methods in Ultrastructural Research", followed by an admirable account of "Principles of Molecular Structure", and succeeding sections consider the role of proteins, lipids, carbohydrates, nucleic acids and mineral salts in biological systems, in each case working up from simple molecules to the complex structures which they form in living material. This is an ambitious project, and in a book of this size, much can be treated only in general outline. Nevertheless the work will provide a useful introduction to the field for students, and others, particularly if used in conjunction with the earlier monograph by Frey-Wyssling, where greater emphasis is placed on cell structure. There are, however, a number of points in the book where one feels that considerable opportunities for arousing interest and enthusiasm have been missed, and where the summaries of recent developments seem lacking in colour and emphasis.

The section on the preparation of specimens for the electron microscope may leave the newcomer unaware of the dominating and almost unbelievably successful part played by studies on sectioned material in contemporary work, despite the technical details which are given of the methods used. The section on X-ray diffraction contains no mention of the fact that helical structures give a specific type of diffraction pattern ; and the omission of any account of hydrodynamic, light-scattering and optical rotation techniques could be criticized.

The section on proteins contains a great deal of useful information attractively presented, but in the treatment of chain configurations, the key part played by the recognition that the X-ray diffraction pattern given by synthetic α-polypeptides was that of a non-integral helix, which could be computed elegantly and in detail, and which agreed closely with that given by the Pauling–Corey α-helix, is slurred over ; and as a result one is left with an impression of vagueness which does less than justice to the evidence. Greater emphasis might also have been given to the importance of the successful application of the heavy-atom technique in X-ray diffraction studies of crystalline proteins.

Muscle and nerve are well covered (although a more extensive discussion of unmyelinated fibres would have been welcome) and the section on lipids is excellent. The section on nucleic acids is rather short in view of the elegance and interest of much recent work in this field. The genetic implications of the specific pairing of the bases required by the Crick–Watson double-helix structure for deoxyribonucleic acid are, surprisingly, not mentioned at all, and the recent work on tobacco mosaic virus, a superb example of the success, interest and importance of careful

and detailed X-ray diffraction studies, is summarized only very briefly, and incorrectly; there is no mention of X-ray work on spherical viruses. On the other hand, the section on the role of mineral salts is extremely interesting and informative.

The principle of giving references, in general, only to key works containing more complete bibliographies has some advantages, but may sometimes leave the reader in the position of having come across tantalizing pieces of information which he can follow up, or the authority of which he can check, only by a prolonged search through the literature.

Despite these criticisms, the book remains a most useful introduction to the subject, and the authors are to be congratulated for their labours in bringing together so much information into one convenient volume.

H. E. HUXLEY

CLASSIFICATION OF THE DIGENETIC TREMATODES

Systema Helminthum

By Prof. Satyu Yamaguti. Vol. 1: The Digenetic Trematodes of Vertebrates. Part 1: Pp. xi+1–980. Part 2: Pp. iii+981–1575. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1958.) 90 dollars; £34 the two parts.

SATYU YAMAGUTI has spent nearly thirty years on the production of his "Systema Helminthum", the first volume of which has now appeared. His work therefore commands the highest respect. Essentially, the book is a compilation of diagnoses of 102 families, 355 sub-families and 1,024 genera of digenetic trematodes, followed by a list of 4,037 references to the original literature, 1,302 illustrations grouped in 106 plates, and an index of the names of taxonomic units and their authors taking up rather more than 130 pages of two columns each. For the assembly of this tremendous fund of information Yamaguti merits high commendation. The diagnostic data are presented in Part 1 under the headings of definitive hosts—fishes, amphibians, reptiles, birds and mammals—which is a useful arrangement so long as it is realized that related species, and even one and the same species, may utilize more than one class of host. The entire taxonomic scheme is set out in Part 2 as an alphabetical list of families, sub-families and genera, whereas the arrangement in Part 1 is neither alphabetical nor the order in which groups may be separated by means of the keys provided. It is disconcerting to the reader to find this apparent disarray; he is prompted to ask why, for example, the relative order of the important families Plagiorchiidae, Lecithodendriidae, Microphallidae, Opisthorchiidae and Paramphistomidae should be 12345 for reptiles but 41325 for fishes, 52431 for amphibians, 14325 for birds, and 12435 for mammals. An alphabetical list has the virtue of ease of reference, even if it does leave unconsidered important questions of affinities.

The classification of the Digenea has generally been on the basis of comparative morphology of the adults, but G. R. La Rue (*Exp. Parasitology*, 6, 306; 1957) has revived the method of utilizing developmental data. His scheme recognizes super-orders, orders, sub-orders, super-families and families and is based particularly on the development of the excretory vesicle and associated parts. Many helminthologists will hesitate to accept it, on the grounds that both larval and adult characters are necessary for the delineation of genetic relationships. As Yamaguti has dealt mainly with adult characters, we can scarcely expect his scheme to provide more than just a list of families. What is striking is the great inequalities of families in this scheme; 13 of the 102 families comprise 10–25 sub-families and 21–106 genera each, making totals of 201 out of 355 sub-families and 551 out of 1,024 genera. At the other extreme, 59 families contain no more than four genera each; 31 of them contain one genus only, 13 contain two genera, 9 three genera and 6 four genera. This aggregate of families comprises only 108 genera and only 30 sub-families are represented. The 30 families yet to be considered have more than four genera and fewer than 10 sub-families each, and we may presume that they comprise 365 genera and 124 sub-families, 16 of the latter with only one genus.

The distribution of Digenea in the classes of host is also unequal; 54 families are represented in fishes, 13 in amphibians, 28 in reptiles, 29 in birds and 36 in mammals. The total exceeds 102 because 58 families are represented in two or more classes of host; the actual number of overlaps is 91, of which 15 involve fishes, 13 amphibians, 21 reptiles, 21 birds and 21 mammals, and the actual number of families involved is 33. Of the families containing one genus only, only the Orchipedidae occurs in more than one class of hosts (birds and mammals); of the remainder, 16 are represented in fishes, 0 in amphibians, 3 in reptiles, 3 in birds and 8 in mammals. The total numbers of families represented in one class of host only are 39 in fishes, 0 in amphibians, 7 in reptiles, 8 in birds and 15 in mammals. Families restricted to two or three classes of hosts number 1 in fishes and amphibians, 3 in fishes and reptiles, 3 in amphibians and reptiles, 1 in reptiles and mammals, and 11 in birds and mammals, and also 4 in fishes, amphibians and reptiles, 1 in fishes, reptiles and birds, and 3 in reptiles, birds and mammals. One family, the Echinostomatidae, is represented in four classes of hosts (fishes, reptiles, birds and mammals), and 5 families are represented in all five classes, namely, the Lecithodendriidae, Opisthorchiidae, Paramphistomidae, Plagiorchiidae and Microphallidae.

A work of this sort could scarcely be free from blemishes of one sort or another. There are many simple misspellings. Fig. 752 (Plate 62) and 1126 (Plate 93) are mislabelled *Pseudopsilotrema*, a name which does not appear in the index, and the names *Saccocoelium* and *Diphterostomum* are misspelt in various places. Many special citations made in the text are not supported by references in the list. For example, the reader's appetite is whetted on p. 184 concerning certain developmental features, a reference is cited and he is invited to see p. 371, where more recent information is given briefly in a second citation; he is then chagrined to find that the second reference is not supplied. Much more serious is the omission of any data concerning the sizes of trematodes and their organs and parts. No pretence is made of dealing with species beyond listing their names and, admittedly, ranges of size are difficult to specify for genera. However, genotypes are specified, and space would have been made available for size data had generic diagnoses been pruned of many redundant expressions which occur in them. Otherwise, some indication of size should have been given with the

figures. The terms used in the text to denote size are useless because undefined. One solitary figure (7, Plate 1) has a scale; 1,301 figures leave the reader baffled regarding size. The figures of *Heterophyes heterophyes* and *Fasciolopsis buski* are about 55 mm. and 52 mm. long, respectively, whereas actual lengths may be 2 mm. and 75 mm. A reader having no foreknowledge of actual differences in size between trematodes may be greatly deceived by the figures, some of which are excellent but others are very poor and too small to be serviceable. He will also be disappointed in the general account of the digenetic trematodes, which barely covers one page and might have been amplified to an interesting and useful statement.

In spite of its shortcomings, the work will be much appreciated by all those who are concerned with trematodes, and its publication is at the same time a remarkable achievement and a notable event. The book summarizes most of the laborious and tedious systematic work which has been carried out, but it does indicate to the enlightened initiate how much research of a synthetic nature remains to be done.

BEN DAWES

HARMONIOUS HERPETOLOGY

A Field Guide to Reptiles and Amphibians of the United States and Canada East of the 100th Meridian

By Roger Conant. (The Peterson Field Guide Series.) Pp. xv+366+40 plates. (Boston, Mass.: Houghton Mifflin Company, 1958.) 3.95 dollars.

DESPITE the number of books that already exist on North American herpetology, until now there has been no up-to-date survey and guide to the reptiles as well as the amphibians of that continent. For many years the little book of Schmidt and Davis provided an accurate guide to the snakes, but with the changes that have taken place in the nomenclature and taxonomy of American herpetology there became an urgent need to revise the "Field Book of Snakes" or replace it with another guide. In 1957, there appeared the "Handbook of Snakes" by Wright and Wright, but in two bulky volumes it could scarcely be considered a substitute for the earlier field guide. The book produced by Roger and Isabelle Conant is the answer to the urgent demand; it is remarkable in that it covers not only the snakes but also all the reptiles and amphibians that are known to occur in North America east of the 100th meridian and yet is of a handy pocket size and is reasonably priced.

The tradition of the Peterson Field Guide Series of combining scientific accuracy with readability has been maintained in this latest volume. In Britain many people are familiar with the "Field Guide to the Birds of Britain and Europe", by Peterson, Mountfort and Hollom, and some may be acquainted with the companion volumes on American birds; all praise the success and outstanding merit of these guides. The field guide to reptiles and amphibians of eastern North America, however, contains several special virtues. The inclusion of distribution maps in the guide to the British birds was at that time an unusual feature, but their value was at once acknowledged and the habit of including maps in check lists and field guides spread to other works. The Conants' book provides a series of well-executed maps which are confined to the end of the book and on which are shown the range of each species and subspecies discussed in the text, so that a check list for any region, state or county can easily be compiled. The photographs are of a superb quality and Mrs. Conant is to be congratulated on the excellent results of her painstaking task of hand dyeing more than 400 of them. Many of the original illustrations were seen by the reviewer, when it was evident that Mrs. Conant had spared no effort in achieving accuracy in colour and detail. Only live animals were photographed. A little of the brilliance of a few of the original illustrations has been lost in reproduction yet no one can deny that for identification purposes the best photographs and colour plates of American reptiles and amphibians are to be found in this book.

The format is essentially the same as in the other guides in the series. Specimens can be identified from the illustrations, with the aid of the salient features of the species listed on the facing page, or from the text where under each species are guides to the identification with notes on voice (in the case of the frogs and toads), size, similarity with other species, and range. Habitat notes and information on habits and natural food are given where known.

The introduction, and the chapters on the techniques employed in collecting reptiles and amphibians, on transporting the specimens, on snake-bite and its treatment, and on the care of the animals in captivity are highly commendable. Although most people will agree on the clumsiness of the term "reptiles and amphibians" when it occurs several times on one page, some purists will be disturbed to find it abbreviated to "herptiles" in this book. Nevertheless, Roger Conant's style is refreshing in its simplicity, and the expressiveness of his descriptions of the mating calls of frogs is worthy of special praise. The voice of the western chorus frog, *Pseudacris t. triseriata*, is likened to the sound produced by "running a finger over approximately the last twenty of the small teeth of a good-quality pocket comb, rubbing the shortest teeth last". Other mnemonics for frog calls range from "loose banjo strings" to "high pitched riveting machines".

"A Field Guide to Reptiles and Amphibians of the United States and Canada East of the 100th Meridian" is an essential companion to the collector of American "herptiles", to those whose interests are in the realms of systematics and behaviour and who require a dependable guide to the identification of the American species and also to the beginner in herpetology.

Mr. Conant has achieved success with his field guide to the eastern species. It is hoped that he will be persuaded to tackle with the same courage and patience a field guide to the herpetofauna of western North America.

A. G. C. GRANDISON

THE ART OF GRAFTING

The Grafter's Handbook

By R. J. Garner. Revised edition. Pp. 260+32 plates. (London: Faber and Faber, Ltd., 1958.) 25*s*. net.

DURING the eleven years that have elapsed since the publication of the first edition of "The Grafter's Handbook" there has been ample proof of its value not only as a long-awaited text-book for the student, but also as a reference book for the practical horticulturist and nurseryman.

There can be little doubt that this revised and enlarged edition will receive an even more enthusiastic welcome, for it covers in detail all known methods of grafting. For those who wish to study seriously the theory and practice of this most fascinating of the gardening arts there is a full description of the methods, their advantages and uses. The author is to be congratulated on the way he has combined the results of his long experience as a practical propagator with the findings of modern research, in which he himself has played an important part at the East Malling Research Station.

A review of this book would not be complete without a word of praise for the publishers and their associates. They have produced a book of high quality, attractively bound and with the pages opening flat, at a modest price.

Prior to the opening chapter, which is devoted to information on the subject of natural grafting and its bearing on artificial methods, there is a glossary of terms used. There are also notes on the reasons for grafting, all of which are of value and interest, particularly to the student.

In Chapter 2 the author discusses compatibility and cambium contact, and the reader is left in no doubt regarding their importance. The following chapters deal with the role of rootstocks and their propagation. There is also excellent information on the collection and treatment of the wood or growths to be used as scions and, to emphasize the importance of the various points, each is dealt with under a separate heading.

Chapter 5 is devoted to "Tools and Accessories", and here the author covers very fully the various knives and other small tools required for the many methods of grafting that he describes. There are also useful notes on the various commodities that are necessary for the completion of the work. This is information that is so often neglected in many books dealing with the practical aspect, while for the student it provides information that is difficult to obtain.

Chapter 6 deals with the many methods of grafting, divided into two main divisions, namely, approach grafting and detached scion grafting. The reader is introduced to each method with clear and concise notes that are supported by excellent line drawings by the author and, in some instances, photographs as well. The way in which this important part of the subject is covered can be judged from the fact that some eighty pages are devoted to this chapter—nearly one-third of the book.

There is much useful information in Chapter 7, which deals with tree-raising in nurseries, and the methods adopted for grafting under glass and in the open are described and commented on. In the next chapter, Mr. Garner deals fully with the methods of grafting used to rejuvenate old trees and to change varieties. There is also information and some excellent illustrations of the methods of grafting employed to repair and save trees that have their bark girdled by animals or damaged in other ways.

The author concludes with a chapter which deals with the misuse of grafting and the interaction of stock and scion. Also discussed are those interesting if not very useful bigeneric trees known as graft-hybrids or chimeras in which an intermixture of tissues occurs to provide in growth a mixture of both genera, as, for example, *Mespilus* and *Crataegus* in *Crataegomespilus*.

A well-prepared index is provided and completes a book that should find a place on the bookshelf of all gardeners and nurserymen, as well as that of the keen amateur.

S. A. PEARCE

UPPER DEVONIAN SPIRIFERS OF THE CATSKILL DELTA

"*Spirifer disjunctus*"
Its Evolution and Paleoecology in the Catskill Delta. By Hugo Greiner. (Peabody Museum of Natural History, Yale University, Bulletin No. 11.) Pp. iv+75+13 plates. (New Haven, Conn.: Peabody Museum of Natural History, Yale University, 1957.) n.p.

FROM a study of numerous specimens of Upper Devonian spirifers (Brachiopoda) from the Catskill delta of New York State, the author claims that what were formerly considered to be varieties of a single species actually constitute a tribe of genetically related species of *Cyrtospirifer*, each having a limited stratigraphic range and belonging to two principal phyletic lines.

The specimens were obtained from littoral or sublittoral beds, mainly sandstones and shales, 2,500 ft. thick, accumulated during 5–6 million years, and ranging from the base of the Chemung to the base of the Mississippian.

Hemmed in by a shore line to the east and by deeper water deposits to the west, the Catskill delta in Devonian times supported some 1,178 species, only a small number of which were near-shore dwellers like *Cyrtospirifer*. The shifting of the delta westwards resulted in sudden changes of facies and the necessity for adaptation of the tribe to various environmental niches.

Six species occur predominantly in sandstone, nine species in shale and three species are found in both shale and sandstone. Most of the species have short ranges, but two showed great adaptability to changing environment and cut across formational boundaries with no marked morphological change, both giving rise to a number of species. The ancestor of the tribe is not known; some species seem to have originated locally while others are migrants from another region, and hybrids are recognized. Early in the evolution of the group there was a considerable number of species probably associated with a narrow sublittoral zone. A broader platform with fewer ecological niches tended to produce fewer species in the later history of the region.

Attenuate forms appear earliest, but alate forms tend to occur in shaly facies and more quadrate forms in a sandy facies, though this is not consistent. Auriculation or mucronation would keep shells on the surface of the mud and prevent currents from upsetting them. The largest shells appeared relatively late.

Lateral costae number about 50 in some early forms, but later forms have about 24 broader costae, while bifurcation of costae within the sinus tends to decrease in the later species.

Small size of adductor scars are said to be indicative of weak muscles which would be suited to quiet muddy sea-floor conditions, while large adductors, coarse costae and thickened ventral umbones distinguish specimens which lived in sandy wave-swept places. The angle of divergence and length of the dental lamellae seem to be variable characters.

As a palæoecological and evolutionary study the paper is of considerable interest, but the identification of the eighteen species (thirteen of them new), some with overlapping ranges and with considerable variation in shell outline, is likely to cause trouble for the taxonomist. No statistical study of the species was attempted.

The paper is well presented, except for a number of misprints, and is illustrated by thirteen plates of excellent photographs.

It is regretted that the author could not have made a rapid survey of European species of *Cyrtospirifer*, and especially *C. verneuili* (Murchison), the type species from the Upper Devonian, Frasnian of Ferques, Boulonnais, which closely resembles some of the Catskill species in form, ornament and spinose micro-ornament. The retention of the name *Spirifer disjunctus* J. de C. Sowerby for the tribe is unfortunate, since this species is doubtfully synonymous with *C. verneuili*, and has actually been assigned to a separate subgenus.

H. M. Muir-Wood

NAMES AND CIPHERS IN ORGANIC CHEMISTRY

Nomenclature of Organic Chemistry, 1957

(International Union of Pure and Applied Chemistry.) Pp. v+92. (London: Butterworths Scientific Publications, 1958.) 15*s*.

A Proposed International Chemical Notation

Prepared by the Commission on Codification, Ciphering, and Punched Card Techniques of the International Union of Pure and Applied Chemistry. Tentative version subject to revision. Pp. vii+165. (London: Longmans, Green and Co., Ltd., 1958.) 35*s*.

THE already embarrassing problems of nomenclature are intensifying through the rapid acceleration of discovery in organic chemistry, resulting in the preparation of more and more complex synthetic compounds and the elucidation of the structures of natural products, often exceedingly complex. The discoverers of necessity invent trivial names, but these convey nothing to the uninitiated. The ideal name for a compound is one which will immediately tell a chemist its structure, enabling him to write down a formula or construct a molecular model. It should also be internationally acceptable, printable and suitable for indexing. There is a natural tendency for a group of workers in a new field to invent a special nomenclature in that field which may or may not be compatible with that in other fields—the steroid field is an example. A vested interest is thus created, and the unfortunate people charged with the task of standardizing meet a dilemma. Editors can do something to discourage this growth of rogue nomenclature by giving advice to authors, as they frequently do, but they may be too late.

In the two books under review we have an opportunity of comparing two entirely different systems of recording and communicating the constitution of any organic compound. The first book accomplishes a great task in revising and standardizing conventional nomenclature in limited fields; the second throws convention to the winds and makes an entirely fresh start, using little that is familiar except the initials of most of the elements.

Serious attempts to obtain international agreement on organic nomenclature date from the Geneva meeting of 1892. The next important development was in 1930, when the Liège rules were drawn up by the Commission of the International Union of Chemistry. A major revision of these rules is now being undertaken, sponsored by the International Union of Pure and Applied Chemistry and in the first book under review we see the first results of this important work. The definitive rules now recommended concern the naming of hydrocarbons of all classes, of heterocyclic systems and of steroids; that is to say, they are concerned with molecular frameworks without substituents, but including derived radicals. Hydrocarbons are divided into classes, aliphatic, monocyclic, fused polycyclic, bridged, spiro and ring assemblies, with a special group for terpenes. In the last group, many trivial names are admitted, with some changes, camphane, for example, becoming bornane. A large list of trivial names is also approved for hydrocarbons of the fused aromatic type, including such newcomers as coronene and ovalene (but not zephrene, I notice). The form biphenyl is adopted for the hydrocarbon which has always been called diphenyl in Great Britain. The systematic naming and numbering of cyclic hydrocarbons of all kinds and of heterocyclic systems follow the conventions of Patterson and Capell's 'Ring Index', so far as I could tell after a careful comparison. (In addition, the useful *a* method of naming heterocyclic fused ring systems as aza, oxa, thia derivatives of a homocyclic parent is given as an alternative to the fusion system. In the field of steroids the Commission has bowed to established custom and accepted the numbering of the cyclopentaphenanthrene system, which flouts all the rules. To simplify nomenclature in this field the use of a number of trivial names is proposed, starting with 5α- and 5β-gonane for the two important stereochemical isomers of perhydrocyclopentaphenanthrene. The volume concludes with some tentative suggestions for nomenclature in the vitamin B_{12} field. The typographical conventions and spellings used in this book are those of *Chemical Abstracts*, which differ appreciably from British usage and the hope is expressed that each nation will attempt to reduce such variations as exist in their publications. In this connexion, the Chemical Society (London) has just announced its intention of making certain changes which will, incidentally, bring its usage more into conformity with American practice. In this review these changes have been adopted.

The ingenious system of ciphering developed in the second book under review is obviously the outcome of careful study. It is based on ideas put forward in 1946 by Dr. G. M. Dyson. Other people at about the same time and later were thinking along similar lines and some of their ideas have been incorporated in the final draft, though essentially it is the Dyson system. The aim is to give an unambiguous cipher to any structure without using any names, trivial or other. This would cut out linguistic difficulties and avoid the strain of having to memorize a multitude of trivial names.

A cipher is composed of letters, figures and punctuation signs. The basic idea is that any structure is made up of chains, rings and functional groups which can be represented by simple signs. A chain of n carbon atoms can be represented by C_n; a saturated ring of n carbons by An; a ring of n carbons having the maximum number of non-cumulative double bounds by Bn; all free valencies are considered to be saturated, so H need not be ciphered except in special cases. The system of numbering enables

junctions, fusions and substituents to be accurately ciphered and it is to be noted that Dyson numbering of familiar rings differs greatly from conventional numbering. It is impossible here to go further into detail but a few examples may be given. Thus, C_4 is *n*-butane; C_4.C,2 is isopentane; C_4.E,1,3 is 1,3-butadiene (E represents a double bond, attached to the first and third carbon of butane); C_2.Q is ethyl alcohol (Q is oxygen, to avoid confusion with zero); $B6_2$ is naphthalene (two benzene rings, B6, fused); B6ZN is pyridine (Z indicates substitution, in this case of one C in benzene by N). Such examples are simple, but complexities soon arise in ciphering structures containing several rings, bridged rings, mixed assemblages of rings and chains and so on, and new rules and conventions have to be devised for these. Among the wonderful ciphers quoted is that for oxytocin, a complex polypeptide, which contains (I counted them) 179 signs and symbols, including full stops and commas, each of which is significant. Deciphering comes to resemble working out a jigsaw puzzle since, with a cipher starting with a number of rings, one has for some time no idea how these are going to be connected in the final structure. Nevertheless, it has been shown that ciphering can be done and the ciphers printed (proof correcting must be a nightmare).

The questions arise, when and how are the ciphers to be used? A few suggestions are made, for example, to use them for differentiating compounds in the major divisions of a formula index. No doubt Dr. Dyson and his colleagues are studying this aspect and will eventually publish their detailed proposals. Ciphering and deciphering will probably be a specialized task in libraries and information centres. The summit of achievement would be an electronic brain to relieve human effort.

E. H. RODD

NEW BIOCHEMISTRY

Annual Review of Biochemistry

Vol. 27. Edited by J. Murray Luck, in association with Frank W. Allen and Gordon Mackinney. Pp. vii+775. (Palo Alto, Calif.: Annual Reviews, Inc., 1958.) 7 dollars.

PROBLEMS that arise from the spate of scientific literature in the world, and in particular in biochemistry, are very real; but at the present time no comprehensive treatment of the problem can be foreseen. Nevertheless the volumes of "Annual Reviews" which appear each year make a sturdy attempt to make a real contribution to the solution of the problem of the digestion of knowledge. As biochemistry draws its pabulum from an ever-widening field of activity the efforts of a reviewer are attended by increasing frustration. The "Annual Review of Biochemistry" is the oldest of the "Annual Reviews" published in California. This twenty-seventh annual volume manages to fashion the torrent of publications in nearly twenty different aspects of the subject into some sort of smooth-flowing stream. Clearly it is not possible to please all the readers all the time, and the specialist can always find material to criticize; but there can be no doubt whatever that the "Annual Review of Biochemistry" is of the greatest importance to biochemists all over the world.

In the present volume, apart from chapters dealing with vitamins, hormones, and the metabolism of protein, fat, and nucleic acids, there are sections concerned with the "Biochemistry of Viruses" (G. Schramm), "Biochemistry of Cancer" (H. E. Skipper and L. L. Bennett, jun.), "Chemistry and Biochemistry of Antibiotics" (E. B. Chain), "Biochemistry of Fishes" (H. L. A. Tarr), "Metabolic Antagonists" (W. Shrive and C. G. Skinner), "Enzymatic Metabolism of Drugs and other Foreign Compounds" (B. B. Brodie, J. R. Gillette, and B. N. La Du). J. A. Stekol again reviews "Biochemistry in the U.S.S.R.".

There is a prefatory chapter, entitled "Impressions of an Organic Chemist in Biochemistry" by Hans T. Clarke, in which the importance of chemistry as a background to biochemistry is particularly emphasized. As an illustration of this thesis one can refer to the review of "Proteolytic Enzymes" by G. H. Dixon, Hans Neurath, and J.-F. Pechère in this volume, which has the conciseness and clarity that one expects from Dr. Neurath and his colleagues. The fact that one is now able to illustrate the activation of trypsinogen and chymotrypsinogen in terms of chemical structures, and can formulate processes which occur at the active centre of proteolytic enzymes by reactions of a chemical type, well illustrates the advances in this aspect of biochemistry. On the other hand, the discussion of "Newer Developments in Relation to Protein Biosynthesis" by H. Chantrenne is one that is at the heart of the dynamic aspects of biochemistry and as yet contains little that can be formulated in purely chemical terms. At heart a biological subject, biochemistry can snatch from the rapidly moving stream of life, systems, bits of tissue, organelles and subcellular particles of all sorts which in their behaviour seem initially to be far from the sort of chemistry that can be discussed in terms of known processes. But the biochemist reduces to manageable proportions the number of the uncontrolled features of the system, and although the processes which ultimately emerge for analysis may be complex they can be treated in terms of chemical reactions. To many, however, the most exciting part of the line of development lies in the early stages. But whichever stage of development is the primary interest of the reader, he will find much to take his attention in this volume of the "Annual Review of Biochemistry".

F. G. YOUNG

FURTHER ADVANCES IN ENZYMOLOGY

Advances in Enzymology and Related Subjects of Biochemistry

Vol. 20. Edited by F. F. Nord. Pp. vii+488. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1958.) 12.50 dollars.

ANOTHER excellent volume of "Advances in Enzymology" contains articles by biochemists from Australia, the United States, Britain, the U.S.S.R., The Netherlands, Sweden and Switzerland; fourteen enzymes are reviewed in some detail, and a number of general topics are also discussed.

There are two reviews on single enzymes by workers who have been personally responsible for much of the recent research described: by Prof. H. Theorell on "Liver Alcohol Dehydrogenase", and by Dr. A. Gottschalk on "Neuraminidase". The first describes some recent kinetic studies, particularly those using fluorimetry, a technique which is critically discussed

and relates them to the picture of alcohol dehydrogenase mechanism developed earlier by Prof. Theorell in collaboration with Dr. B. Chance. The second review is particularly devoted to the chemistry of the substrates concerned, sialic acids.

Prof. H. M. Kalckar discusses the enzymes involved in the metabolism of uridinediphosphogalactose, and the function of this compound in animals and bacteria. Drs. Vischer and Wettstein list the enormous range of transformations of steroids carried out by micro-organisms; few of these have yet been associated with isolated enzymes, and it is clear that this will be a fruitful field for the enzymologist. Drs. Deuel and Stutz discuss pectic substances and their breakdown, the emphasis being placed on the chemistry of the substrates rather than the enzymes.

A particularly important review is that of Prof. E. C. Slater on "The Constitution of the Respiratory Chain in Animal Tissues". There is still a great deal of uncertainty about several parts of the oxidation chains in animal mitochondria, and the more controversial points are clearly and persuasively discussed. Powerful arguments are urged, for example, against the view that cytochrome *b* is not involved in succinate oxidation, and against the participation of vitamins E and K in the main coenzyme-linked chain. The nature of the cytochrome reductase reaction and the function of the other cytochromes are further topics dealt with in detail; the importance of cytochrome c_1 is emphasized.

Two articles deal with the mechanism of enzyme action. Drs. Davies and Green give a clear and concise account of recent work on the mechanism of cholinesterase, especially that stemming from studies on the inhibition of the enzyme by diisopropyl fluorophosphonate. They conclude that a great deal remains to be done, particularly in explaining the differences between individual enzymes sensitive to diisopropyl fluorophosphonate which appear to have considerable similarities in amino-acid sequence at the active centre. This article may be usefully read with that of Drs. Barnard and Stein, who discuss the role of histidine in the active centres of enzymes. The chemistry of imidazole derivatives is described in detail, and the article will be of use to the many enzymologists who speculate on these matters.

Much has been written in recent years from the enzymic point of view about mitochondria and other structures in animal cells, but less has been written about plant sub-cellular structures. The gap is well filled by an account by Prof. Sissakian of the "Enzymology of the Plastids". Many enzyme systems besides those directly concerned with photosynthesis have been detected in chloroplasts, and these enzymic results are highly significant when considering the function of these bodies.

A more metabolic topic is dealt with by Dr. Kretovich, who discusses the importance of glutamine and asparagine in the nitrogen metabolism of the plant, in protein synthesis and so on. Prof. Werner Kuhn, in an article entitled "Optical Activity and Aging", develops his earlier ideas on asymmetric synthesis and loss of optical purity. Finally, the usual article on some topic on the fringe of enzymology is by Drs. Tanner and Beesch on the interesting results so far obtained by the use of antibiotics such as streptomycin in the control of plant diseases.

All in all, the volume will provide good reading for any biochemist for many a long winter's evening.

EDWIN C. WEBB

RADIOACTIVE ELEMENTS

Chemistry of the Rare Radioelements
Polonium-Actinium. By Dr. K. W. Bagnall. Pp. x+177+5 plates. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1957.) 30*s*.; 5 dollars.

Uranium and Thorium
By L. Grainger. Pp. viii+204+8 plates. (London: George Newnes, Ltd., 1958.) 25*s*. net.

"CHEMISTRY of the Rare Radioelements" is a specialized book which describes the chemistry of the elements polonium to actinium. It is of interest to note that, of these elements, only radium could be obtained in a pure state and in weighable amounts prior to 1939. At the present time, however, more is known about the chemistry of polonium than any of the others. This is in no small part due to the extensive programme of work carried out by the author during the past few years at Harwell. He is well qualified to write this book, and the standard he has set is surprisingly high considering the meagre amount of reliable published work on which he had to rely.

The author points out that our knowledge of the chemistry of polonium is approaching in extent that of tellurium, its lower homologue in the Periodic Table. This is largely due to the development of new microchemical techniques for handling polonium—and it should be remembered that this still usually represents work with sub-milligram amounts of the element. There are two short chapters devoted to the handling of polonium and radium and actinium. While these are useful, it would have been preferable to confine them in one chapter in which health problems and micro-radiochemical techniques were discussed in somewhat more detail.

About half the book is devoted to an exhaustive treatment of the chemistry of polonium, and this is a valuable contribution to all inorganic chemists. It is to be hoped that more work, of similar calibre, will be published on actinium. Thus, while milligram quantities of actinium metal have been prepared, most of the solution chemistry is based on tracer scale work, and this can be notoriously misleading. A reason for the small amount of work with actinium is, of course, the difficulty in estimating the isotope actinium-227, because of its weak β, and complicating decay chain. It is surprising the author has not described the use of the α-counting method, which, although requiring a good counter and a pulse analyser, is quantitative and reliable.

This is a valuable reference book and is recommended to all who are interested in the rarer elements.

As the author points out in the preface, "Uranium and Thorium" is intended to provide a reasonably comprehensive picture of the technology of uranium and thorium. It is not intended for the specialist in the metallurgical problems of nuclear power, but it does provide a good background for other scientists and engineers who are either directly concerned with the production of nuclear power or who are just interested in knowing more about uranium and thorium.

The book is, broadly speaking, divided into three parts. The first gives a good account of the occurrence, ore-processing methods and metal production of both uranium and thorium. Then the chemical and more particularly the physical properties of both

metals and their compounds are discussed. The last two chapters give a short account of the use of uranium and thorium as nuclear fuels and current trends in fuel-element design in each of the countries interested in nuclear power reactors.

The subject-matter is largely drawn from the proceedings of the 1955 Geneva Conference. Although there has now been a second conference (1958), the book is still surprisingly up to date, and in a second edition it is the chapters dealing with fuel elements which will require more extensive revision. There is also an increasing amount of work being carried out on uranium alloys, for example, with zirconium, molybdenum and silicon, but these receive only a mention. The physical properties of such systems are of interest to the physical metallurgist, and their applications are of special interest to the nuclear technologist. This is a subject which might well merit a chapter to itself.

The author, who at the time this book was written was chief metallurgist to the Industrial Group of the United Kingdom Atomic Energy Authority (he is now chief metallurgist at Harwell), is well qualified to produce such an authoritative account. The book, which is reasonably priced, is strongly recommended to all those interested in the use of uranium and thorium in nuclear power production.

G. R. HALL

SATELLITE RESEARCH

Scientific Uses of Earth Satellites

Edited by James A. Van Allen. Second, revised edition. Pp. x+316. (Ann Arbor, Michigan: University of Michigan Press; London: Chapman and Hall, Ltd., 1958.) 75*s*. net.

THIS book contains an account of experiments which were proposed for the American satellite programme to be carried out mainly during the International Geophysical Year. The various chapters are based upon papers presented at a meeting of the Upper Atmosphere Rocket Research Panel in 1956 by a number of experts in the field of planetary physics. In the first edition, now almost two years old, the experiments were presented as proposals, no satellites having been launched at the time, but since then several of those suggested have been successfully carried out, and others are upon the point of being tried. The second edition now under review, coming so soon after the first, could scarcely be expected to give an account of the results so far obtained, and in fact no new material has been added. Some of the thirty-three chapters have, however, been revised and brought up to date, although this has not altered the total number of pages in the book (316). Revisions may be found in Chapter 1, where, for example, equation 42, p. 9 (which gives the motion of the line of the apsides of a satellite orbit) and the sentence following it, have been corrected. A short addendum has been made to Chapter 24, and in Chapter 33 the discussion of electron accretion by an interplanetary dust particle has been rewritten. There are other changes of a similar nature throughout the book.

The real value of the book, which must be judged to be considerable for those working in the various fields covered, lies in the basic nature of the treatment of each subject. Chapters 1, 5 and 11 discuss in some detail satellite orbits with perturbations due to the Earth's oblateness and atmospheric drag. Further perturbations arising from time and latitude variations of air density and from winds are perhaps too scantily treated to satisfy those interested in the behaviour of the recent *Sputniks* and their rockets. The visibility of satellites and optical tracking problems are the subjects of Chapters 2, 3 and 4, although no detailed mention is made of systems now in use. Satellite instrumentation is covered in a general way in Chapters 6 and 7, power sources being given considerable attention, and particular experiments for the study of the density and pressure of the Earth's atmosphere from a satellite, namely, by an accelerometer recording drag on an orbiting inflated sphere and by an ion gauge of special design, are detailed in Chapters 10 and 12.

The study of the meteorology of the Earth by observing tropospheric weather systems as revealed by clouds is proposed in Chapter 13. The method involves scanning the Earth by narrow-angle photoelectric detectors in a spinning satellite, the detector outputs being telemetered to a chain of ground stations. Chapter 14 describes a method whereby it should be possible to obtain the temperature of the atmosphere as a function of the optical depth by observation of the thermal radiation from the Earth and its atmosphere in the far infra-red.

Four chapters are devoted to investigations in the ultra-violet, which include continuous monitoring of the Lyman alpha-emission from the Sun, observations of the resonance radiation at 1216 A. arising from sunlit hydrogen atoms in interplanetary space, and a prediction of the appearance of the sky in the ultra-violet based upon the study of ultra-violet stellar magnitudes. (No mention is made in the latter of the recent discovery of hitherto unsuspected ultra-violet emitting objects.)

Chapters 20, 21 and 22 are concerned with cosmic rays and auroral radiations. It is here again that a suggestion that the second edition might be somewhat premature could arise, owing to the absence of a discussion of the extremely important Van Allen radiation belt discovered by an American satellite vehicle.

The four succeeding chapters describe proposed geomagnetic measurements of the main field and atmospheric current systems, Chapters 23 and 24 being particularly extensive. Instrumentation is given in some detail, and the importance of establishing the presence or absence of an extra-terrestrial ring current is naturally stressed.

Ionospheric studies occupy five chapters, mainly from the aspect of propagation experiments. Chapter 28 briefly describes possible temperature and electron density measurements using a Langmuir probe.

Chapter 32 reviews work on the acoustic detection of meteoric particles, already carried out using rockets, and recommends the technique for satellites. An alternative meteor detector based on the erosion of resistive elements on the outside surface of a satellite is briefly described in Chapter 8. Interplanetary dust is further discussed in Chapter 33, particular attention being paid to the motion of charged dust particles near the Earth.

Each chapter includes a list of references, in general very extensive, but there is no index. Diagrams are clearly reproduced, and chapter sections and sub-headings well displayed.

E. B. ARMSTRONG

Science and Religion in Seventeenth-Century England

By Prof. Richard S. Westfall. (Yale Historical Publications, Miscellany 67.) Pp. ix+235. (New Haven, Conn.: Yale University Press; London: Oxford University Press, 1958.) 36*s*. net.

IN view of its importance as a landmark in human history, it is not surprising that the seventeenth century is receiving special attention from both historian and scientist. The present book is not merely one of many, it has a distinct approach of its own; indeed, the publishers claim that it "is the first attempt to study systematically the religious opinions of seventeenth-century scientists in the light of their importance to the future of Christianity". As the word "virtuoso" constantly occurs, Prof. Westfall wisely explains that he uses it to describe "one who has a general interest in arts and sciences, or who pursues special investigations in one or more of these; the meaning is further restricted to those interested specifically in natural science". The term appears in the title, the "Christian Virtuoso", published by Boyle in 1690.

The book under review contains many illustrations from the writings of the virtuosi on such subjects as the harmony of science and religion; the harmony of existence; Divine Providence and natural law; the growth of natural religion; reason and faith. Among the familiar names specially mentioned are Robert Boyle, Nehemiah Grew, John Locke, John Ray and Edmond Halley. It is fitting that the concluding chapter of Prof. Westfall's work should be headed "Isaac Newton: A Summation". It begins with an extract of Newton's letter to Richard Bentley, dated December 10, 1692: "When I wrote my treatise about our system, I had an eye upon such principles as might work with considering men for the belief of a deity; and nothing can rejoice me more than to find it useful for that purpose". There are references also in this chapter to Newton's theological writings, and a discussion of his views in relation to those of the other virtuosi.

The inclusion of a "Bibliographical Essay" of some ten pages enhances the value of Prof. Westfall's book, and invites further study of an outstanding period in science, religion and philosophy.

H. D. Anthony

Le Système du Monde

Histoire des Doctrines Cosmologiques de Platon à Copernic, Tome 8. Par Prof. Pierre Duhem. Pp. 512. (Paris: Hermann, 1958.) 3,400 francs.

THE posthumous publication of Vols. 6–10 of Pierre Duhem's monumental work "Le Système du Monde" has now proceeded to the eighth volume, being the second of a group of three which is devoted to the physics of the Parisian school in the fourteenth century. The first two chapters (8 and 9) deal with the problems of the vacuum: its possibility, the so-called *horror vacui* of Nature, the movement of bodies *in vacuo*. In the next two chapters (10 and 11) the movement of falling and projected bodies is treated. This is a most important subject in medieval physics, as it contains the germ of modern dynamics. Then the treatment turns to cosmology again: the application of the ideas of the Terminists on celestial motions is discussed and the various attitudes of medieval thinkers towards astrology are reviewed. As was remarked in the review of the preceding volume, we owe a debt of deep gratitude to the editors for the fact that the great work that Duhem left unfinished at his death in 1916 is none the less being completed. In the meantime, however, the study of medieval science has been pursued and our ideas on the subject have notably progressed. It is no longer possible to consider Duhem's statements and opinions as final, as we all were inclined to do when the first volumes of "Le Système du Monde" appeared in the years 1914–17. Nowadays no reader striving after a knowledge of medieval science which is abreast of the time can afford to neglect studying the works of A. Maier. This, however, necessitates some important modifications in Duhem's exposition.

This does not detract from the pleasure of reading him. His style is an admirable specimen of French elegance and clarity from which it is no detraction that some corrections are necessary in the text.

E. J. Dijksterhuis

Benedict de Spinoza

The Elements of His Philosophy. By Prof. H. F. Hallett. Pp. xvi+171. (London: The Athlone Press, University of London, 1957. Distributed by Constable and Co., Ltd.) 25*s*. net.

THIS is a compact, scholastic exposition of Spinoza's philosophy, the result of profound reflexion on the original texts. There is no evaluative discussion of Spinoza's ideas; Prof. H. F. Hallett has tried to speak only with his master's voice. His book provides a remarkable example of sympathetic understanding, in attitude and intellect, of a lapsed mode of thought, and it will unquestionably be illuminating for the expert in studies of Spinoza—and for those who thought they were experts. But I fear that to the rest the book will remain closed not long after it is opened. The author's scholastic style expresses itself continually in sentences such as, "A perfect primordial being possesses all potency in eternal act; but an imperfect and privative being possesses only the potency that it actualizes, though, as privative, potency is durationally available to it that is not *by it* durationally actualized" (p. 6), which might well discover truths to the initiated but can only baffle the novice for whom the book is confessedly designed. Again, the background to Spinoza's thinking, the patterns and pressures that moulded his mind and the materials that he transformed in his own peculiar way are neither elucidated nor referred to; and the principal scholarly work (by Wolfson) which provides this very background is nowhere mentioned, not even in the bibliographical note. Thus my reaction to Prof. Hallett's mature and careful presentation is one of respect and admiration, mixed with regret at his stylized obscurity and at the absence of historical enlightenment.

Peter Nidditch

ESP and Personality Patterns

By Gertrude Raffel Schmeidler and R. A. McConnell. Pp. xiii+136. (New Haven, Conn.: Yale University Press; London: Oxford University Press, 1958.) 25*s*. net.

SOME years ago, at the City College, New York, Dr. Schmeidler discovered that if she asked her experimental subjects whether or not they believed in the possibility of extra-sensory perception (ESP), their subsequent scores showed that the believers' average score was significantly above mean chance expectation, whereas the unbelievers tended to score at chance-level or slightly below. She labelled these

two groups the 'sheep' and the 'goats', respectively. Later experiments have amply confirmed this original finding, and it is one of the not very large number of facts in experimental parapsychology that can be regarded as established.

This fact is interesting, since it is not only an addition to the evidence as to the reality of extra-sensory perception, but also an indication that there are personality differences correlated with ESP ability It leads to many further questions, some of which are further explored in this book; many of which are indicated but not yet answered. The obvious further question as to a more exact specification of the personality correlates of ESP ability has been tackled mainly with the help of the Rorschach test. Since, however, this test is known to have low reliability, no very certain evidence as to the answer has been obtained or is likely to be obtainable by this means. The suggestion by the authors, that some of the diversity in findings of different investigators of this topic may be due to personality differences between investigators, is an important speculation that awaits experimental verification.

The experimental work of Dr. Schmeidler has until now been scattered in the technical journals. In collecting it in one volume and in obtaining the collaboration of Dr. McConnell (particularly for a needed strengthening on the statistical side), she has done the student of parapsychology a considerable service. The result of this collaboration is an interesting and authoritative account of an important piece of research.

R. H. THOULESS

The Black Fens

By A. K. Astbury. Pp. xi+217+55 plates. (Cambridge: The Golden Head Press, Ltd., 1958. Distributed in Great Britain and Eire by W. Heffer and Sons, Ltd.) 42*s*.

THIS excellent book is likely to appeal most to the layman interested in finding out more about one of the most distinctive regions of Britain, but also has much of interest to geographers. The first part of the book is concerned with the origins and physical characteristics of the black peats, which since the beginnings of major drainage schemes in the seventeenth century have come to provide Fenland farmers with exceptionally productive soils. But agriculture in the Fens faces a unique combination of hazards. There can be few areas in the world where, within the span of one year, a farmer may have to contend with his soil being flooded in winter and actually catching fire in summer. Since draining, the peat has shrunk many feet while the silt river beds have maintained their original height. These processes make control of surface-water progressively more difficult and the consequences of a failure of flood protection measures more serious. The problems of farming, and of building roads, railways and houses upon the spongy peat are illustrated with a wealth of detail that obviously springs from a long and intimate acquaintance with the area. Particularly to be commended is the use of carefully selected aerial photographs printed opposite sketch maps of the area covered by them, which serve to show the great importance of the "roddhams". These silt beds of ancient water-courses provide the only stable sites for building in the peat region.

In the second part of the book the question of the origin of the Fen waterways is examined. It is remarkable how little is known about most of these ancient channels. After an exhaustive study of many of them, based on considerable field work, the author puts forward a good case for believing that many of them were constructed by the Romans, but rightly points out the difficulty of proving this or any other hypothesis.

The book is well served by many good photographs and sketch maps and a large folding map which shows nearly all the places mentioned in the text.

M. A. MORGAN

Bone and Radiostrontium

By Arne Engström, Rolf Björnerstedt, Carl-Johan Clemedson and Arne Nelson. Pp. 139. (New York: John Wiley and Sons, Inc.; Stockholm: Almqvist and Wiksell; London: Chapman and Hall, Ltd., 1957.) 70*s*. net.

ANY information concerning the metabolism of strontium-90 must be welcomed at the present time and the authors have presented a valuable account of work carried out in their own laboratories. One chapter is devoted to a discussion of the distribution of mineral salts in bone in which the techniques of microradiography and microinterferometry are fully described. In another chapter the authors discuss the nature of bone salts and the structure of bone tissue, particularly with reference to the ability of the apatite crystals to attract various types of ions by surface adsorption. A calculation of the radiation dose from beta-rays within a plane parallel sandwich of radioactive trabecular bone and inactive bone marrow is described in great detail. It is a pity that the authors did not also include calculations using cylindrical geometry, which might be more applicable in the case of another concentration site of strontium-90, namely, Haversian systems.

In the discussion summarized at the end of the book, the authors deduce a value, 0·1 μc., for the maximum permissible burden of strontium-90 in human beings. Since this is 10 per cent of the value recommended by the International Commission on Radiological Protection for occupationally exposed persons, the authors' arguments have been carefully examined. The radiation dose within a microscopic tissue element in bone contaminated with the radio-isotope has been discussed in relation to an assumed cancer dose of 1,000 r. of external radiation. There is, however, no discussion about the importance of the relationship between dose or dose-rate and the incidence of cancer, or of the importance of the volume of tissue irradiated. A comparison between a body burden of 0·1 μc. strontium-90 and an unspecified burden of radium known to produce malignancies is, of course, valueless. There is in any event no comment about the effect of alpha- and beta-particle range on the non-uniformity of radiation-dose or about the relative biological effectiveness of the two radiations. A second calculation assumes that a dose of 10 r. to a microscopic site in bone marrow will produce detectable blood changes. In the absence of a more detailed discussion on the type of blood damage expected, on the dose-response relationship and on the effect of varying the time over which the dose is given, this discussion is also without value.

It is unfortunate, therefore, that the authors, who obviously have a valuable contribution to make in this field, did not make a more careful survey of the present position before attempting to suggest a new level for the maximum permissible burden of strontium-90.

J. VENNART

Lebensgemeinschaften der Landtiere

Ihre Erforschung unter Besonderer Berücksichtigung der Zoozönologischen Arbeitsmethoden. Von Dr. Janos Balogh. Zweite verbesserte und erweiterte ausgabe des 1953 erschienenen werkes "Grundzüge der Zoozönologie". Pp. ii+560. (Budapest: Akdemiai Kiado, 1958.) n.p.

THE Budapest school of terrestrial biology is well known for its work on the ecology of the soil fauna. Dr. J. Balogh's book is of value because it introduces this important work to a wider audience, but it is perhaps of even greater significance as a synthesis of theory and of methods of analysis current in the different world schools of community ecology.

The first edition of this book was a stimulating and thoughtful analysis of animal synecology, logically beginning with definitions of the community (biozonose) and later departures from earlier concepts, followed by an analysis of the community, its detection and delimitation, its structure and subdivision, its inorganic and living content, spatial and temporal changes, the food chain and production biology and finally a consideration of schemes of analysis and study in practical use. The new edition has been extended so that it is now an up-to-date and cosmopolitan account of this field. To this have now been added sections which provide the most extensive review now in print of methods for the collection, examination, culture and extraction of terrestrial invertebrates, supplemented by sections on vertebrates by Turček and on agricultural land faunas by Heydemann (of Kiel). Although statistical aspects of sampling are not considered, no one who already works in this field can fail to find some useful details of technique which will be new to him, and no one entering the field could be referred to a more complete résumé of methods. A. MACFADYEN

The Dawn of Life

By Dr. J. H. Rush. Pp. 258. (London: English Universities Press, Ltd., 1958.) 15s. net.

DR. J. H. RUSH has made a brave attempt to present a comprehensive account of the origins of living matter in terms intelligible to those without much knowledge of physics and chemistry. He has a rare skill for interpretation, and is adept both at choosing the right word and in using a suitable figure of speech for illuminating his text. Yet it is doubtful if his book can be called more than a gallant failure. Although the grand strategy is clear and well-conceived, the tactics are scarcely suitable to achieve the objective.

Besides descriptions of the hypothetical beginnings of the universe and the earth, the author includes accounts of the physico-chemical origin of living things, theories of evolution, life on other planets and the emergence of mind. All this, supported by the relevant laws of physics and a description of chemical theory, does not make for easy reading even for those with some knowledge of chemistry and physics. Like so many books intended for the general reader, the author has attempted too much in too short a space. If the first three chapters had been expanded and written with the intelligent secondary modern schoolboy in mind, Rush might well have produced an outstanding popular scientific work. He is to be congratulated for this attempt, and should be encouraged to write other popular works with the belief that sometimes greater clarification is achieved more by omission than commission. T. H. HAWKINS

An Introduction to Tropical Agriculture

By Sir Harold Tempany and D. H. Grist. Pp. xvi+347+12 plates. (London and New York: Longmans, Green and Co., Ltd., 1958.) 40*s*. net.

THE late Sir Harold Tempany has attempted "to provide a logical and coherent account of the background to agriculture in the tropics", which his co-author believes "should be of great value to students, agricultural officers and administrators" in these areas. Sir Harold, who had had a wide experience of tropical agriculture, died before completing his task, which was then entrusted to Mr. D. H. Grist. With the increasing demand for tropical agricultural products and the urgent need to improve methods of land use and production and thereby raise the living standards of many tropical peoples, such a book should be very welcome, particularly as no such account had been published for some years. Unfortunately, the volume under review does not reach a standard adequate to meet this need.

The book is very uneven in content. Much space is wasted in explaining simple facts which are more adequately dealt with in the numerous elementary text-books on temperate agriculture. Thus a whole chapter is devoted to fertilizers in which the role of the major elements in plant nutrition and the nature of the common fertilizers are explained, while shifting cultivation, the most important system of farming in the tropics, with its wide range of variation and modern modifications, is dismissed in one page. The treatment of many subjects is so generalized, uncritical and superficial that it provides little information of practical value and some of it is inaccurate. It is possible to quote many statements of the obvious which might well have been omitted, such as "irregularities in the amount and incidence of rainfall cause great difficulties and these naturally increase as the drier regions are approached", which appears in almost identical words no less than three times in two consecutive pages. J. W. PURSEGLOVE

Flora of Manitoba

By H. J. Scoggan. (National Museum of Canada Bulletin, No. 140.) Pp. v+619. (Ottawa: Queen's Printer, 1957.) 5 dollars.

THE province of Manitoba is larger than the United Kingdom and is centrally placed in Canada both physically and botanically, but by a trick of fate it had remained uncovered by the three great manuals dealing with the flora of temperate North America. This neglect is now remedied by the excellent book under review. The major vegetation types of Manitoba are prairie (now mostly under cultivation), swamp and dry sandy forest near the Great Lakes, boreal forest, tundra forest and arctic tundra in the extreme north-east. These are briefly described, with their climates, and are illustrated by photographs. The rest of the book, apart from a bibliography, tabular classifications of species and lists of additions and exclusions, is the Flora proper, which follows many conventional lines.

There are no descriptions of individual taxa, and critical taxonomic comment is cut to the minimum, but the specific keys seem unusually ample and satisfactory, and there are many references to recent generic revisions. Careful notes are given on habitat and on distribution both within and outside the area, the "first report" of each taxon is always cited and so too, usually, are the "earliest collection seen" and the northernmost collection. Hybrids are omitted:

otherwise, there would surely be some mention of this proclivity among the 28 species of *Salix*. 1,417 species of vascular plants, including 193 introductions, are found in Manitoba, the largest families being the Cyperaceae (159 native species), Compositae (144) and Gramineae (114). No less than 118 species of *Carex* are listed, but there is no genus comparable, at any rate in treatment, to the British *Rubus* and *Hieracium*. The author is to be congratulated on a valuable piece of work which will reward the close scrutiny of British and European botanists concerned with the preparation of Floras. N. Y. SANDWITH

Diseases of Domestic Animals in New Zealand

Prepared by the Technical Committee, N.Z. Veterinary Association, Inc. Pp. x+240. (Wellington: Editorial Services, Ltd., 1958.) 35*s*.

THIS book is not for the arm-chair reader but for the busy veterinary surgeon needing some form of reference to which he can turn for essential and up-to-date factual information. It deals with the significant diseases of domesticated animals and poultry, only as they occur in New Zealand, grouped under the headings, bacterial, viral, protozoal, fungal, parasitic, nutritional and metabolic, those caused by poisons, and miscellaneous. Under each heading, the diseases are listed alphabetically, and each disease is covered in one or, at most, two pages in précis form through the use of subheadings, for example, species affected, notifiable, distribution, occurrence, herd incidence, etiology, mode of infection, signs, pathology, diagnostic aid, prognosis, treatment, etc. The brevity of style and standard form of presentation have been used deliberately for ease of reference, so that one is presented with an accurate and authoritative summary of the disease position in New Zealand. Some minor criticisms could be made. As one example, it is a little distracting to find that all the intestinal nematodes of a particular host animal are treated as causing one disease. Such criticism, however, is trifling and amply compensated by the wealth of information presented so simply and concisely and with so few errors. There is an index of eight pages which could, with advantage, have contained more entries such as helminths, cestodes, trichostrongyles or even worms, to mention a few. The eight appendixes listed in the contents table were not included in the reviewer's copy. J. N. OLDHAM

Birds of Cyprus

By Dr. David A. Bannerman and W. Mary Bannerman. Pp. lxix+384+31 plates. (Edinburgh and London: Oliver and Boyd, Ltd., 1958.) 63*s*. net.

ONE has come to expect volumes from Dr. Bannerman that are sumptuous as well as scholarly, and here he and his wife present another. The scale may even seem luxurious for the avifauna of so small a territory, but Cyprus has a considerable ornithological literature and its bird-life shows interesting features. The island lies on the fringe of the tremendous migrations of the Levant, and more than half its 333 recorded species are purely birds of passage; others are winter visitors. Some 70 species breed, a third of them as summer visitors: among the residents, 14 belong to races peculiar to the island. It is remarkable that, in spite of extensive forests, there are no woodpeckers and no nuthatch.

There are references to birds going back to the fourteenth (falconry only) and sixteenth centuries; serious ornithological publications date from 1787 onwards; in the past few years ornithologists in the Armed Forces have added numerous records; the Bannermans themselves spent some months on the island in 1954 and in 1957–58 for the purposes of the book, and they have drawn both on the other sources and on their own observations. For the benefit of the student in Cyprus, there are notes on identification (with numerous figures) and on extra-limital distribution: Greek and Turkish names of species are given. For ornithologists elsewhere, the information about local status is of importance as a contribution to a wider pattern. The illustrations include some fine colour plates by D. M. Reid-Henry and Roland Green. LANDSBOROUGH THOMSON

British Fermentation Industries

By J. M. Whitmarsh. Pp. xiv+133. (London: Sir Isaac Pitman and Sons, Ltd., 1958.) 25*s*. net.

THIS condensed account of industrial fermentations, which is restricted to British practice, embraces both old and new processes, but deliberately excludes consideration of the potable and antibiotic industries. The manufacture of industrial alcohol, acetone and butanol, lactic acid, vinegar, baker's yeast, citric acid and of sorbose is described as illustrative of the older processes. The inclusion of the obsolescent industrial alcohol and acetone-butanol processes, both of which have been superseded by synthetic chemical processes, is justifiable in that they have provided, over a number of years, fundamental knowledge and technological experience which has facilitated the rapid large-scale development of newer processes. It is especially valuable to have good condensed accounts of these new, less-familiar, processes as exemplified by those by which vitamin B_{12}, riboflavin and dextran are manufactured and by which difficult steroid transformations may be effected; for it is in these fields, as well as in that of antibiotic production, that the fermentation industries may be expected to continue to develop and prosper. In all, Dr. Whitmarsh has written a very useful account of the subject within his self-imposed restrictions. Despite compression, there is adequate technical detail to provide a good introduction to the fermentation industries for new entrants, of whom the biochemical engineer should be particularly mentioned. There are few errors of fact or of typography, but the taxonomically minded will boggle at reading that *Euglena* is a mould (p. 82) and that *Rhizopus nigricans* is a *Mucor* species (p. 115).

Textbook of Biochemistry

By Prof. Benjamin Harrow and Prof. Abraham Mazur. Seventh edition. Pp. ix+557. (Philadelphia and London: W. B. Saunders Company, 1958.) 52*s*. 6*d*.

PROF. Benjamin Harrow has a long and honourable career as a writer of text-books of biochemistry. In 1935 he and Carl P. Sherwin collaborated as joint editors of a "Text-book of Biochemistry" to which chapters were contributed by a number of authorities. This book set a standard of clarity and breadth of information which was upheld later by a text-book with Prof. Harrow as the sole author, of which editions have already appeared ranging from the first in 1938 to the sixth in 1954. For the sixth edition Prof. Harrow was joined by Prof. Abraham Mazur as joint author, and now a seventh edition is called for, as might be expected, four years after the sixth.

Since the rate at which biochemistry develops continues alarmingly, each edition of a general text-book needs substantial revision, and the new edition of this standard work has been widely revised. In particular, the chapters on nucleoproteins and the various phases of intermediary metabolism have been rewritten, and the previous one on photosynthesis replaced by sections in the chapters on carbohydrate chemistry and on carbohydrate metabolism. It is a reflexion of the coherence of growing knowledge that changes of this sort now are almost inevitable. The former two chapters on digestion and adsorption have been incorporated into one, while that with the title "Detoxication" has been quite properly replaced by one called "Metabolism of Organic Chemicals".

With the immense growth of knowledge of which account is taken it is surprising, but welcome, that this edition should be a little smaller than the previous one. The pages of text, numbering more than 500, are still eminently readable, and although some sections naturally are less up to date than others, on the whole the authors keep surprisingly well abreast of current knowledge. They are to be congratulated on maintaining a standard text-book in such a uniformly good state. F. G. Young

General Biochemistry

By Prof. Joseph S. Fruton and Prof. Sofia Simmonds. Second edition. Pp. xii+1077. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1958.) 144*s*. net.

THIS book gives a very complete and readable account of the chemistry, physical chemistry and intermediate metabolism of the important chemical constituents of the living organism. The chemical chapters on proteins are extensive and provide a most detailed and informed survey. A chapter on elementary thermodynamics with a useful introduction to the second law and the concept of free energy is also included.

The whole of the subject-matter is introduced and developed as an experimental science, and sufficient experimental details are given for a proper appreciation of the theoretical discussions and generalizations. In many cases the experimental methods are described and explained in some detail, and this is especially true of the more recent methods of chromatography and isotopic tracer techniques.

All the usual metabolic sequences and interconversions of biological syntheses and degradation are ably discussed, and generally the most recent views and enzymic steps are included. These metabolic surveys are mainly concerned with animal biochemistry, although there is a very good chapter on photosynthesis by green plants.

The book is thus an excellent and comprehensive introduction to the subject, and since it is well documented it may well serve for a few years as a reference book to some parts of biochemistry. However, as a text-book for use by students in Great Britain it has two disadvantages. One of these is its very high price and the other is the level at which it is written. For use in most elementary courses the book is too detailed, especially for those students who do not wish to specialize in the subject; while the advanced student, although finding the book very useful, must have access to the many adequate reviews and whenever possible direct reference to the important original papers. D. H. Northcote

Metals and Enzyme Activity

Biochemical Society Symposium No. 15 held at the University of Leeds on 13 July 1956. Organized and edited by E. M. Crook. Pp. v+102. (Cambridge: At the University Press, 1958.) 21*s*. net cloth bound; 15*s*. net paper bound.

IN the Biochemical Society symposium held at the University of Leeds, in 1956, inorganic chemists and biochemists joined in discussing aspects of the functions of metals in enzyme systems. This book contains the papers that were presented at that meeting, together with the discussions which followed.

The symposium opened with a short introductory paper by R. S. Nyholm describing recent work on metal ligand bonds, a topic which was developed further in a paper by L. E. Orgel on the solution chemistry and structural chemistry of some metals important in enzyme activity. Some suggestions on the mode of action of metals in the catalytic hydrolysis of peptide bonds were made by B. R. Rabin, who gave a short account of conflicting views on the nature of the enzyme–metal-substrate complex. Later in the session, F. C. Happold and R. B. Beechey considered the univalent metal ions as non-specific activators of enzymes and attempted to explain their function. The role of metals in metallo-flavoproteins was summarized by F. Bergel and B. C. Bray, who discussed the involvement of the metals in electron-transfer reactions. The symposium ended with a paper by E. C. Slater describing briefly and conveniently the classification and properties of the cytochromes.

This meeting of chemists and biochemists has made a valuable contribution to this fascinating problem, and it is unfortunate that more than two years have passed before the papers appeared in print. O. T. G. Jones

Electronic Theory and Chemical Reactions

An Elementary Treatment. By R. W. Stott. Fourth edition. Pp. viii+112. (London and New York: Longmans, Green and Co., Ltd., 1958.) 12*s*. net.

THE author was one of the first to attempt a simplified account of the theories of reaction mechanism and his success may be measured by the fact that this is a fourth edition of a book which first appeared a little more than fifteen years ago. This edition retains the very simple treatment which characterized the earlier editions, together with additions and emendations. The bibliography which accompanies each chapter has also been extended and is now, in some cases, of considerable proportions.

The content of any book is largely a matter for the author, and his success in this case suggests that he caters very satisfactorily for his intended readers. Nevertheless, I feel that some change of balance in the material might be made in a future edition. There is, for example, no discussion of hydrogen-bonding, while about four pages are devoted to a demonstration of the equivalence of the hydrogen atoms in benzene. This latter, formal demonstration might be curtailed or even eliminated by mentioning the Raman and infra-red spectral evidence that this molecule is planar and centro-symmetrical. The X-ray evidence upon hexamethylbenzene, or benzene itself, may be quoted instead. Inclusion of the former topic would do much to remove the difficulty that not all covalently bonded compounds are of a high volatility, 100 per cent sulphuric acid being a particular example.

A few minor errors have also appeared in the text. Thus, the omission of a negative charge from the extruded group X^- in the bimolecular substitution process on p. 53, the reference to a diagram as on p. 65 which is really on p. 67, the possible confusion which may arise (p. 85) by describing Cl^- as a chlorine ion instead of the established chloride, the more so as possibly a Cl^+ is involved in this reaction, and finally, the reference p. 62 should be to Braude and not Brande.

The book is well and pleasingly produced and adequately indexed. One can confidently look forward to the appearance of a further edition within the near future. R. I. REED

Fundamentals of Optics

By Prof. Francis A. Jenkins and Prof. Harvey E. White. Third edition. Pp. vii+637. (London: McGraw-Hill Publishing Company, Ltd., 1957.) 64*s*.

IN its third edition, this excellent text-book has been largely rewritten to include recent developments in both experiment and theory, and to bring the treatment into line with modern ideas on the teaching of the subject. There can be few books ranging from the detailed drawing-board computations of ray-tracing, and the analytical discussion of third- and fifth-order aberration, to the scintillation counter and its possible use to examine simple interference experiments in the light of the uncertainty principle. The mathematical proofs of formulae have been presented more concisely, and the complex-quantity notation used in the wave-theory section of the book makes for easier reading. The diagrams, many of which illustrate graphically the physical meaning of an analytical expression, are really helpful in supplementing the mathematics. The book is well produced, and can be recommended as very good value. G. R. NOAKES

Nuclear Magnetic Resonance

Annals of the New York Academy of Sciences, Vol. 70, Article 4. By H. S. Gutowsky and seventeen other authors. Pp. 763–930. (New York: New York Academy of Sciences, 1958.)

A CONFERENCE on nuclear magnetic resonance was held by the New York Academy of Sciences in November, 1957, and the papers presented at this meeting have now been published. The papers are concerned with some of the more recent applications of nuclear magnetic resonance to chemical problems. The first part deals with the fundamental interactions which determine the nuclear resonance line-widths and shapes, their chemical shifts and multiplicities. The origins of these interactions are summarized by C. P. Slichter, and H. S. Gutowsky gives an excellent review of the chemical interpretation of chemical shifts and spin – spin coupling constants and of the principles of the analysis of the sometimes complex high-resolution spectra. This is followed by a description by Schneider, Bernstein and Pople of the detailed analysis of the very complex spectra of pyridine and its deuterium derivatives. The study of hindered internal rotation in organic molecules is discussed by W. D. Phillips, and of chemical exchange kinetics by W. G. Schneider and L. W. Reeves. P. C. Lauterbur describes experiments to explore the use of the spectra obtained from carbon-13 nuclei in natural abundance in organic compounds. The use of high-resolution nuclear resonance spectra to study really complex organic molecules is illustrated by F. C. Nachod and by M. Saunders and A. Wishnia. The complementary use of nuclear magnetic resonance and infra-red spectra is discussed by H. Finegold with especial reference to the chemistry of organic compounds of phosphorus, and R. B. Williams gives a detailed and authoritative discussion of the conditions necessary for the use of nuclear magnetic resonance for quantitative analysis.

For the reader with some acquaintance with the subject of radio-frequency spectroscopy, this collection of papers provides an excellent survey of the uses of the method in chemistry.

R. E. RICHARDS

The Preparation of Programs for an Electronic Digital Computer

By Dr. Maurice V. Wilkes, Dr. David J. Wheeler and Dr. Stanley Gill. Second edition. (Addison-Wesley Mathematical Series.) Pp. xiv+238. (Reading, Mass.: Addison-Wesley Publishing Company, Inc.; London: Academic Books, Ltd., 1957.) 60*s*.

THIS is a second and enlarged edition of the book first published in 1951. As before, the main emphasis is on the preparation of programmes for *Edsac* I together with the specification and detailed coding of selected library sub-routines. Additional material has been added, however, on machines possessing different order codes and different input and output systems, while twelve pages are devoted to automatic programming and the concept of 'floating addresses'.

The book is in three parts, its basic plan following that of the first edition. Part 1 gives all the information required to prepare a programme for the *Edsac* and deals in general terms with other machines. Part 2 specifies the most important of the *Edsac* library sub-routines and Part 3 gives the complete list of instructions for selected sub-routines.

The book will be of most value to the beginner who wishes to learn some of the principles underlying programming. In particular those intending to programme *Edsac* I will welcome the revised description of the order code, in which important changes have occurred since the publication of the first edition. These include the provision of a *B*-register, the unconditional jump order and output on to punched paper tape.

The use of the machine is clarified by a number of simple examples, and exercises—many with specimen solutions provided—are set to enable the reader to test his understanding of the machine.

The book has a more attractive layout than previously, and the authors are to be commended on this revised edition. E. L. ALBASINY

Fourier Transforms and X-ray Diffraction

By Prof. H. Lipson and Dr. C. A. Taylor. Pp. vii+76. (London: G. Bell and Sons, Ltd., 1958.) 18*s*. 6*d*. net.

THIS is a well-prepared book at a comparatively moderate price, suitable for third-year undergraduates and junior postgraduates, but containing much that will interest senior research workers and university teachers. When the theory of X-ray diffraction by crystals is approached by way of the Bragg relation, the transition to the reciprocal lattice can often seem highly artificial, and the idea of the molecular transform may never be reached at all, especially by the non-mathematically inclined. The authors argue convincingly that if what is interesting is the content of one unit cell, then it is more logical

and may be more fruitful to begin with the transform and examine its modification by the crystal lattice. The means of doing this optically, which is a subject of which they have special experience, is only briefly mentioned in an appendix, and is to be dealt with in a further publication. Applications of the Fourier transform theory to the trial-and-error method, to sign determination, to the direct recognition of molecular features, to structural imperfection such as stacking disorder, to the effects of crystal size and shape and other problems are given brief but stimulating consideration. In dealing with temperature effects, however, the impression is given that the diffuse regions around all reciprocal lattice points are similar and parallel, and this is an error which should be corrected in the next edition.

KATHLEEN LONSDALE

Introduction to Difference Equations with Illustrative Examples from Economics, Psychology and Sociology

By Prof. Samuel Goldberg. Pp. xii+260. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1958.) 54s. net.

IN recent years new developments in the social sciences, economics, psychology and sociology have involved an increasing use of mathematics, and a branch of the subject which has found widespread application is the theory of difference equations. The book under review covers this topic and is "primarily intended for social scientists". The exposition is at an elementary level, and the style is sufficiently easy for the ordinary undergraduate to understand the methods for solving difference equations and to learn of some of the recent research applications such as inventory analysis and probability models for learning.

Two features of the book deserve special mention. There are a number of worked-out examples to illustrate the text and more than 250 problems with answers, so that the work should be very useful as a text-book. There are also many references to recent research papers, where the research student may find more detail. Altogether the book gives the impression of having been carefully written and with the student very much in the mind of the author.

Some topics of a relatively advanced nature are gently introduced towards the end. These include matrix methods, generating functions, a characteristic-value problem and the analysis of equilibrium and stability. The latter, unfortunately, is only discussed in the case of a second-order auxiliary equation, and the reviewer believes that it would have been useful to discuss the case of higher-order equations, via the Routh-Hurwitz determinantal conditions.

L. S. GODDARD

An Introduction to Combinatorial Analysis

By John Riordan. (A Wiley Publication in Mathematical Statistics.) Pp. xi+244. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1958.) 68s. net.

THE classical text-book by Netto, "Lehrbuch der Combinatorik", published in 1901, is unknown to most present-day mathematicians; and the subject-matter, namely, problems of enumeration, has been generally out of favour for two decades or more. Now the book under review appears and new life is thereby injected into the subject. The author has given a careful exposition of various developments of recent decades which have until now remained locked away in scattered journals and proceedings. Perhaps the most valuable aspect of the present work is this bringing together of material and the connected account of a topic which is important in various branches of applied mathematics and probability theory, as well as in certain parts of pure mathematics where there is still an interest in finding 'the number of ways'.

For the contents an introductory chapter on permutations and combinations is followed by an important chapter on generating functions, including the polynomials of E. T. Bell. Then there are chapters on the principle of inclusion and exclusion, cycles of permutations, distributions and occupancy. The next chapter, which comes near to parts of graph theory, is concerned with partitions, compositions, trees and networks. The explicit results find application in the theory of electrical networks and in systems engineering, including coding problems in data transmission. The last two chapters cover permutations with restricted position.

The book includes a large number of problems and explicit results at the end of each chapter. These are for the serious student who wishes to know 'how to do it' rather than what has been done. They are, as the author says, "put in a form to aid rather than baffle", and they assume, as does the text itself, a considerable degree of mathematical maturity on the part of the reader.

L. S. GODDARD

Technology of Instrumentation

By Prof. Eric B. Pearson. (Applied Physics Guides.) Pp. 202. (London: English Universities Press, Ltd., 1958.) 25s. net.

INSTRUMENTS are indispenable in modern scientific and engineering work, and an understanding of the principles of operation is essential if correct results are to be obtained. The main emphasis is on the performance of the standard laboratory milliammeter type of instrument. The static and dynamic characteristics of instruments are explained and the importance of a knowledge of the transient response of an instrument is demonstrated. Electronic instruments are not included, and it is unfortunate that the cathode-ray oscilloscope is omitted since it is valuable where non-sinusoidal wave-forms are to be measured.

The application of instruments to control systems occupies the larger part of the book. The principles of servomechanisms are dealt with at length, and topics discussed include velocity feedback, reduction of velocity lag and general conditions for stability. A chapter on servomechanism components describes a number of elements used for measuring the difference in angular position of output and input shafts of a mechanism. This is followed by a description of electronic and hydraulic amplifiers and motors for supplying power to an output shaft. The final chapter on instrumentation of mathematics describes a number of electrical and mechanical devices for integrating and multiplying.

The book forms a useful introduction for students in the subjects of instrumentation and servomechanisms, but it is unfortunate that the author has not considered a wider range of measuring instruments and measurement principles.

R. L. GRIMSDALE

(*Continued from p.* 950)

Ano-dorsal fin formula. Adult specimens collected by Frost in Kenya have shown that this character cannot be used alone to distinguish between even adult *A. n. labiata* and *A. mossambica*, although *A. b. bicolor*, the 'short-finned eel', is immediately recognizable by this method and is not represented in the present material. Figures for this character are given in Table 1.

Vertebral counts. In both the Tana and the Sabaki specimens the vertebral counts are rather low. Thus Barnard[6] considers 100–105 normal for *A. mossambica*, and Frost (*in litt.*) 107–115 for *A. n. labiata*. But even with X-ray photographs, such counts are difficult in the smaller specimens and an error of two or perhaps three vertebræ is possible.

The eighteen Tana River elvers have been referred to *A. n. labiata* and the single Sabaki River elver is considered to be *A. mossambica*, the first true elver to be recorded in Kenya. There is no doubt from the abundance of adults in the river at certain times of the year that elver and post-elver stages must migrate upstream in considerable numbers, and further observations at the Merilla Barrage and the construction of an elver trap on the Ragati River (Tana system) at our Inland Fishery Research Station should reveal much of interest.

We are grateful to Dr. W. E. Frost for additional adult measurements and for helpful comment on these observations, and we are especially indebted to Dr. Geoffrey Kelham, of Nairobi, for some strikingly successful X-ray photographs of these difficult small subjects.

VERNON D. VAN SOMEREN
PETER J. P. WHITEHEAD

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Game and Fisheries,
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'Bat Erosion' at Niah Great Caves

AT the Great Caves of Niah, Sarawak, West Borneo[1], there is a relatively soft coral limestone of Miocene date in which these vertical cavities are common, and as in Trinidad[2], found where there are no stalactites. On the other hand, the rock in these places is damp and there may often be a ring of very slowly forming drips around the mouth of a cavity. Moreover, only small family groups of *Miniopterus witkampi* regularly use these sites as roosts, rarely more than five at once, hanging in a bunch from the top-dead-centre[3]. It is doubtful whether the scrabbling action of these small bats could ever excavate such cavities, and indeed the remarkable symmetry and the vertical axis of each formation suggests that it is due to solution rather than the activity of bats.

Nevertheless, at least two species of bat at Niah are responsible for erosion of different sorts in the cave. The small *Hipposideros galeritus* (a roundleaf horse-shoe bat) roosts singly and there are certain spots on the cave wall where a bat may be found every day. Here the action of the bats' claws keeps a small area of the surface rough and free from the slimy coating that covers it elsewhere in the deep interior. This roughened patch is often slightly concave, perhaps worn by mechanical erosion.

More positive is the effect of the huge, densely massed colony of *Cheiromeles torquatus* (the naked bat), which occupies a large gallery at one of the highest points of the roof. Fragments of rock quite often fall from this site and are deeply eroded and heavily stained with the bats' excrement. Presumably chemical action weakens the limestone until it breaks under its own weight or under the burden of a *Cheiromeles*, which weighs about six ounces.

Examination of the bat-remains recovered at mid-palæolithic levels in the 1958 Niah dig prove the presence of both *H. galeritus* and *Cheiromeles* at levels corresponding to an age of well over 40,000 years[4], as well as other bats no longer found in the cave[5]; so that, if occupation has been continuous, both these species have had plenty of time to leave their mark.

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Galeal Structure in Adult Mosquitoes

IN a previous communication[1], studies of the finer structure of the galeæ in adult mosquitoes were reported. It was pointed out that the galea formed the functional maxilla and typically consisted of a strengthening chitinous rod with a fine outer lamella the tip of which carried a number of variously shaped teeth. Further studies, ranging over eight genera of mosquitoes of the Ethiopian region, have revealed that although there is a variety of morphological types, a progressive reduction in the outer lamella is evident. It should be noted that generic and specific differences in the mouth parts of adult mosquitoes have only been poorly investigated[2], and early studies described only general morphological differences in the trophi, usually of species of known medical and veterinary importance[3–5]. In the present studies, freshly killed mosquitoes were used whenever possible and the heads were soaked in 5 per cent potassium hydroxide for 48 hr. After this they were transferred to a slide, the trophi teased apart with a fine steel point and mounted in polyvinyl alcohol. General examination was carried out at ×100 and detailed examination at ×450.

It has been found that there are four main types of galeal structure which are shown diagrammatically in Fig. 1. Type *A* has a well-developed outer lamella with the distal portion expanded and typically small teeth without pointed tips. Type *B*, which has a simple blade-like appearance, is the commonest form found and the teeth are subject to wide variation in both form and number although the greater proportion are elongate with pointed tips which extend beyond the outer margin of the lamella. Type *C* has the terminal region of the lamella reduced, but this is

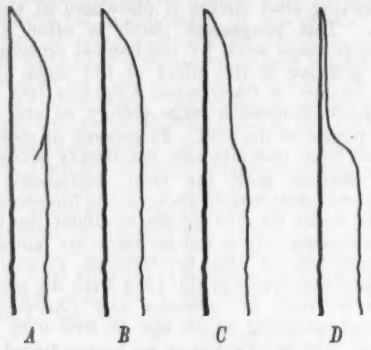

Fig. 1. Diagrammatic representations of the four types of galeal structure as described in the text, showing the progressive reduction of the terminal region of the outer lamella. The teeth typically carried on the lamella are not shown

never less than half the width of the main portion of the lamella. The teeth vary in size and form, but most project beyond the margin of the lamella. Type *D* has the terminal part of the lamella further reduced and in all observed cases this was less than half the width of the main portion. In the majority of cases the teeth were seen to project beyond the margin of the lamella. The species possessing these four types of galeal structure are shown in Table 1.

Table 1. Species possessing the Types of Galeal Structure as Described and Figured

Type *A*: *Uranotaenia balfouri, U. annulata, Aedes simpsoni.*
Type *B*: *Anopheles gambiae, A. demicolus, Hodgesia nigeriae, Uranotaenia bilineata, Mansonia metallicus, M. annetti, M. africanus, M. uniformis, Eretmapodites semistriplices, Aedes longipalpis, A. apicoargenteus, A. stokesi, A. simulans, A. dendrophilus, A. irritans, Culex horridus, C. fatigans, C. decens, C. annulioris, C. cinerellus.*
Type *C*: *Anopheles coustani, A. rufipes, A. pharoensis, Uranotaenia ornata, U. philonuxia, U. caliginosa, Aedes aegypti, A. africanus, A. pseudoafricanus, A. luteocephalus, Culex duttoni.*
Type *D*: *Ficalbia hispida, Eretmapodites chrysogaster, Aedes circumluteolus, A. argenteoventralis, Culex tigripes, C. albiventris, C. nebulosus.*

It is difficult at this stage to establish any satisfactory relationship between the galeal structure and the feeding habits of the species. The genus best represented in this study, *Aedes* Mg., possesses each type of galea but nearly all the species represented are known to be anthropophilic in some degree. It must not be overlooked, however, that genera do exist which are capable of biting but have not been observed to do so, while most species take blood for the purpose of ovarian maturation[6]. Thus it would seem that there exists a series of galeal forms represented by the successive reduction of the terminal region of the outer lamella which is not related to feeding method. In the previous communication already mentioned particular attention was paid to the finer structure of the outer lamella and in these present studies further observations have been made upon it. In the great majority of species examined the outer lamella has been seen to have a particulate nature, the individual portions being at right angles to the chitinous rod or directed slightly posteriorly. Early workers[7] stated that this lamella was divided into separate areas by transverse lines which in some cases produced indentations of the outer edge, while it has also been recorded that this structure was essentially membranous with only fine and sometimes anastomosing striations. The present observations tend to support the former view, although the particulate nature was noticeably absent in most *Aedimorphus* species.

Finally, mention must be made of the teeth attached to the galeal lamella. The maxillary index (the average number of teeth on the two maxillæ) has been shown to be related to the power to infect in anopheline mosquitoes[9] and has also been used for demonstrating different races in mosquitoes of the same species but bred from different habitats[10,11]. On the other hand, it was also established that the maxillary index of adults bred from the same egg batch was subject to a wide variation[12]. In the present studies the variations in the number of teeth is considerable, but due to insufficient data concerning feeding habits it is not possible at this stage to construct any well-defined relationship between this activity and maxillary index.

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Jan. 6.

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Antimicrobial Substances from Resistant and Non-resistant Seeds

Why certain plant varieties are resistant to plant pathogenic micro-organisms while others are not resistant is not understood. It is possible that resistant plants produce more antibacterial and antifungal substances than non-resistant plants in order to protect themselves against microbial invasion. This idea was advanced by Irving, Fontaine and Doolittle[1] and was tested by Little and Grubaugh[2]. The latter investigators used the expressed juices of several resistant and non-resistant common garden plants and tested them against both plant and animal pathogenic micro-organisms. They concluded that no distinction could be drawn between the activities of the juices of resistant and non-resistant plants. Similar results were reported by Tims[3]. It was thought advisable to investigate seeds in an attempt to demonstrate any difference between resistant and non-resistant plants. Furthermore, the solvents used in the preparation of seed extracts was not only water but also di-ethyl ether, acetone, ethyl alcohol (95 per cent) and *n*-butyl alcohol. The use of organic solvents for removing antimicrobial substances from plants is the more common procedure[4,5].

The media used for growing the bacteria was a nutrient agar and broth, while the fungi were cultivated in Sabauraud's dextrose agar and broth. The following seven test organisms were employed: *Serratia marcescens, Escherichia coli, Staphylococcus aureus, Mycobacterium smegmatis, Candida albicans, Erwinia caratovora,* and *Streptomyces venezuelae*. Five additional plant pathogenic micro-organisms were also tested against some of the seed extracts. All bacterial cultures were incubated at 37° C. for 24 hr.

Table 1. ANTIMICROBIAL ACTIVITY OF RESISTANT AND NON-RESISTANT CABBAGE SEEDS

Seeds	Zones of inhibition (mm.)							
	E. coli	*S. aureus*	*S. marcescens*	*S. smegmatis*	*C. albicans*	*E. caratovora*	*S. venezuelae*	*F. oxysporum f. conglutinans*
Jersey Queen*								
Water extract	7	2	6·5	2	4·5	11	10	1
Diethyl ether extract	5·5	7·5	2	9	4	5	9	7·5
Acetone extract	6	8	2	9	6·5	5	10	4·5
Ethyl alcohol extract	5·5	8·5	0	9	4·5	5	8	3·5
n-Butyl alcohol extract	2·5	6·5	0	5	0·5	2·5	5	3
Detroit*								
Water extract	7	8	2	9	2·5	7	10	1
Diethyl ether extract	5	9	3	10	6	8	9	10·5
Acetone extract	5	9	3	13	7	8	10	10
Ethyl alcohol extract	5	10	3	12	6	8	10	9
n-Butyl alcohol extract	6	9·5	2·5	12	6	6	10	9
Danish Ball Head								
Water extract	*0·5*	*3·5*	*0*	*3*	*0·5*	*0·5*	*3*	*0*
Diethyl ether extract	0	4	0	4	1	1	2·5	0
Acetone extract	0	4·5	0	5	0·5	2	3·5	0
Ethyl alcohol extract	0	1	0	1·5	0	0	1	0
n-Butyl alcohol extract	*0*	*1*	*0*	*1*	*0·5*	*0*	*1*	*0*
Penn State Ball Head								
Water extract	7	1	4	2	0	10	9·5	0
Diethyl ether extract	0	3	0	3	0	1	2	0
Acetone extract	0	0	0	0·5	0	0	0·5	0
Ethyl alcohol extract	0	1	0	0·5	0	0	0	0
n-Butyl alcohol extract	0	0	0	0	0	0	1	0

* Jersey Queen and Detroit are resistant, Danish Ball Head and Penn State Ball Head are non-resistant seeds. 0 signifies zone of inhibition absent. All zones are from disk edge to zone edge.

except *S. venezuelae* (24-hr. incubation at room temperature), *E. caratovora* and *Pseudomonas phaseolicola* (48-hr. incubation at room temperature). All the fungi were incubated at 37° C. for 3 days except the following plant pathogens which were incubated at room temperature: *Helminthosporium victoriae* strain *1 and strain 6 (4-day incubation); Ustilage avenae* strain 38–1, strain 38–2, strain 38–3 (7-day incubation); *Colletotrichum lindemuthianum* (7-day incubation); and *Fusarium oxysporum* f. *conglutinans* (2-day incubation).

Extracts of all seeds were prepared as follows. 20 gm. of the dry seeds were added to 50 ml. of solvent and allowed to soak for 1 hr. The material was next macerated in a Waring blendor for 2 min., then filtered. The aqueous extracts were passed through a Seitz filter. Filter-paper disks (6·35 mm. diam.) were saturated with each extract and allowed to dry in air. The procedure was repeated so that each disk contained four applications of extract. The filter-paper disk method[6] was used for determining the presence of antimicrobial activity. In this method 1 ml. of microbial broth culture was added to approximately 10 ml. of melted agar in sterile Petri dishes and allowed to solidify. The prepared disks were then placed on the surface of the seeded agar and incubated. Measurements of zones of inhibition surrounding the disks were recorded with a millimetre ruler and an illuminated Quebec colony counter. All experiments were conducted six times.

The following varieties of bush bean (*Phaseola vulgaris*) were found to possess no activity against the seven test organisms or against *C. lindemuthianum* and *P. phaseolicola*: Contender (resistant), Tender Long (resistant), and Black Valentine (non-resistant). Pinto Bean III (resistant) and Pinto Bean Tenderpod (non-resistant) were found to exhibit the same negative results. Extracts prepared from the following varieties of oat (*Avena sativa*): Navarro (resistant), LMHJA (resistant) and Tama (non-resistant) showed no activity against the seven test organisms or on *H. victoriae* strain 1 and 6, *U. avenae* strains 38–1, 38–2 and 38–3. Of the extracts prepared from different varieties of cantaloupe seeds (*Cucumis melo*), di-ethyl ether extracts of Delicious (resistant) and Honey Rock (non-resistant) showed slight activity on two of the seven test organisms. However, cantaloupe Honey Ball Pink Flesh (non-resistant) and cantaloupe No. 5 Powdery Mildew (resistant) showed no activity against all seven test organisms. Results with extracts from cabbage seeds (*Brassica oleracea* var. *capitata*) listed in Table 1 indicate that resistant cabbage seeds possess greater amounts of antimicrobial substances than do non-resistant seeds.

The antimicrobial substance present in cabbage plants is known as rapine[7]. It may be this organic polysulphide[8] that is present in greater amounts in resistant cabbage seeds than in the non-resistant variety. Failure to obtain any antimicrobial activity from other resistant seeds studied in this investigation cannot be explained. Perhaps the antimicrobial substances are liberated during seed germination. Studies in this field are now in progress.

We wish to thank Dr. J. S. Tidd (Asgrow Seed Growers Inc., Connecticut) for his generous supply of seeds; Dr. L. L. Dean (University of Idaho) for bean varieties; Dr. H. C. Murphy (Iowa State College) for oat varieties; Dr. H. H. Luke (University of Florida) for cultures of *Helminthosporium victoriae*; Dr. W. J. Zaumeyer (U.S. Department of Agriculture) for *Colletotrichum lindemuthianum*; and Dr. C. S. Holton (University of Washington) for cultures of *Ustilago avenae*.

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Oxygen Deficiency and Radiation Damage in the Insect *Rhodnius*

Reduction in radiation damage under conditions of low oxygen tension during the exposure has been demonstrated in a number of plant and animal tissues[1]. This report deals with similar effects in the insect *Rhodnius prolixus*. Latent radiation damage in 'resting' cells of the epidermis of *Rhodnius* is expressed as a burn at delayed moulting following a blood meal[2]. In these studies, the delay in moulting and the size of the burns have been utilized as convenient indices of the oxygen effect during X-irradiation.

Unfed 4th instar nymphs were irradiated on the dorsal surface of the abdomen through a hole, 1·6 mm. diam., drilled in a lead shield 5 cm. in thickness[2]. During exposure (at 16 cm. from the target of a 2 MeV. X-ray machine; dose-rate 6,000 r. per min. as measured in air without the shield) the insects were enclosed in a small chamber through which either air or nitrogen was circulated at a rate of 3 litres per min., after bubbling through water at room temperature. *Rhodnius* can be held in nitrogen for periods of 45 min. without injury; however, the insects are completely immobilized after 1½ min. The nymphs were held in either air or nitrogen for 10 min. prior to irradiation. After exposure they were fed and returned to an incubator at a constant temperature of 25° C. and a relative humidity of 75 per cent.

Throughout the dose-range employed in these experiments, and for both criteria of damage, the effect inflicted by irradiation in air was two to three times that produced when the same dose was delivered in nitrogen (Fig. 1). The delay in moulting following irradiation at the lowest dose in nitrogen was barely perceptible (controls moult in 14 days), but was large after an equal dose in air. Burns did not develop after exposure in nitrogen at doses below 120 kr., but they were invariably present with doses as low as 60 kr. in air.

Thus, oxygen deficiency produces a considerable amount of protection from X-irradiation in the epidermal cell layer in *Rhodnius*. As indicated previously, and confirmed by unpublished cytological studies, the delay in moulting is due to mitotic inhibition in the epidermis prior to moulting. The inhibition of division is particularly striking in this organism because the epidermal cells enter division synchronously at a fixed time after a meal of blood. The ratio between the dose in air and the dose in nitrogen that produces equal effects is between 2·5 and 2·6, a value that agrees with those given by Evans *et al.*[3] for mitotic delay.

Further details of these experiments will be published elsewhere.

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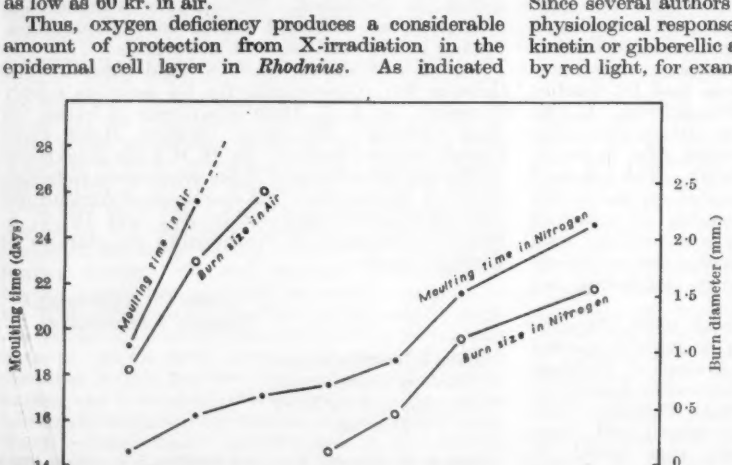

Fig. 1. Moulting times and sizes of burns of 4th instar *Rhodnius* nymphs irradiated in air and in nitrogen. Each point represents the mean from the results with five individuals. Two insects died during ecdysis after exposure to 100 kr. in air (moulting time indicated by dotted line); the burns were measured after death. The moulting time after feeding for unirradiated controls under similar conditions of temperature and humidity was 14 days

Effects of Kinetin, Gibberellic Acid and Certain Auxins on the Development of Shoot Buds on the Protonema of *Pohlia nutans*

During recent investigations[1] on the effects of light of various wave-lengths on the development of the protonema and the formation of shoot buds in *Pohlia nutans* (Hedw.) Lindb., it was discovered that buds were formed only in light which included the red region of the spectrum. Furthermore, experiments on the supply of various concentrations of sucrose or glucose to the protonema suggested that the effect of red light was not merely a trophic one, but that a specific formative stimulus was probably involved. Since several authors have found that certain of the physiological responses of various flowering plants to kinetin or gibberellic acid are similar to those induced by red light, for example the expansion of leaf tissue and the onset of germination in certain dormant seeds, it seemed that it might be of interest to study the effects of these two physiologically active substances on the development of the protonema and the initiation of shoot buds in *Pohlia nutans*.

Aseptic cultures were prepared from small protonema inocula on a standard Knop's agar, with addition of various concentrations of kinetin, kinetin + 0·1 mgm./l. indoleacetic acid, gibberellic acid and, for comparison, 0·1 mgm./l. indoleacetic acid. The cultures were grown under artificial light from fluorescent tubes ('Natural') giving 375 foot candles at the level of the cultures. The temperature was regulated at 22–24° C. Another series of cultures was grown with addition of vari-

Table 1. Effects of Various Growth Substances on the Radial Growth of the Protonema and on Bud Formation in *Pohlia nutans*. Mean diameter of cultures in mm.* and number of buds (*B*)† in brackets

Dates‡	Aug. 31, 1957	Sept. 10, 1957	Sept. 25, 1957	Nov. 11, 1957
Gibberellic acid				
100 mgm./l.	15	27§	38	54
10 ,,	19	35	53 (15·3 *B*)	67
1 ,,	22	35	50 (17·8 *B*)	64
0·1 ,,	22	33	50 (12·2 *B*)	64
Kinetin				
10 mgm./l.	14§	22	35	50
1 ,,	15§	24	37	47
0·1 ,,	16§	24	37	51
Kinetin (+ 0·1 mgm./l. indoleacetic acid)				
10 mgm./l.	18‖	29	41	55
1 ,,	17‖	25	36	54
0·1 ,,	17‖	27	42	56
Indoleacetic acid				
0·1 mgm./l.	17	28	40 (7·8 *B*)	56
Control	19	32	49 (9·6 *B*)	67

* Mean measurements of three similar Petri dish cultures.
† Number of buds on the date when they were first observed in the cultures.
‡ Cultures started on August 14, 1957.
§ Large number of buds.
‖ Many buds.

ous concentrations of the three auxins: indoleacetic acid, naphthaleneacetic acid, and indoleacetonitrile. The results obtained with the first series of cultures are summarized in Table 1.

It will be seen from Table 1 that all the concentrations of kinetin supplied, whether with or without the addition of indoleacetic acid, resulted in the early appearance of a large number of shoot buds on the protonema; in fact, the number formed was so great that it was both impracticable and unnecessary to carry out counts of shoot buds for comparison with bud formation on the other protonema cultures. With gibberellic acid there was a similar stimulation of bud formation at the highest concentration used (100 mgm./l.), but the three lower concentrations had relatively little effect. Neither gibberellic acid nor kinetin had any great effect on the growth of the protonema. With the three auxins tested, there was complete inhibition of bud formation in naphthaleneacetic acid at all three concentrations, 0·1, 1·0 and 10 mgm./l., in indoleacetic acid at 10 mgm./l. and in indoleacetonitrile at 50 mgm./l. A reduced number of buds was produced in indoleacetonitrile at 1 mgm./l. and at 10 mgm./l. The inhibition of bud formation in indoleacetic acid and naphthaleneacetic acid is in agreement with results obtained by previous workers[2,3]. Indoleacetonitrile had apparently not been tested previously.

The results with kinetin and gibberellic acid are of interest in that not only is the number of buds increased but also the date of their first appearance advanced as compared with the control cultures. Gorton and Eakin[4] similarly observed that kinetin increased the number of shoot buds on the protonema of *Tortella caespitosa*, but in contrast with the results reported here, they failed to obtain any earlier appearance of the buds in the presence of kinetin. We are not aware of any previous study of the effects of gibberellic acid on the development of buds on moss protonemata, although its action on the growth of the protonema has been followed in *Splachnum ampullaceum*[5].

It may be concluded from the present work that kinetin and gibberellic acid can both stimulate the formation of buds on the protonema of *Pohlia nutans*, and in this respect are similar in action to red light. It remains to be seen, however, whether these substances can promote the development of buds on a protonema which has been maintained throughout its growth in complete darkness.

We are indebted to Prof. E. Boyland, Chester Beatty Research Institute, for the supply of kinetin, and to Dr. P. W. Brian, Akers Research Laboratories, for the gibberellic acid.

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CYTOLOGY

Some Effects of Colchicine on Lampbrush Chromosomes

Isolated lampbrush chromosomes from the oocytes of many vertebrates have been subjected to various treatments to obtain information about the basic structure and organization of chromosomes. Lampbrush chromosomes are ideally suited for studies of this kind for they are long (350–850μ), easily isolated and can be treated without fixation and viewed immediately with an inverted phase microscope system[1,2]. This enables the experimenter to observe the action of the reagents upon the chromosomes soon after treatment and with minimum handling.

Solutions of pepsin, trypsin, ribonuclease and deoxyribonuclease have been applied to lampbrush chromosomes. Where the first three reagents destroy the material coating the lateral loops without destroying the linear integrity of the chromosomes, deoxyribonuclease effects a fragmentation of the lateral loops and of the axis of the chromosomes to which the loops are attached. Gall[3] has shown by electron microscopy that although the coating surrounding the loops is destroyed by pepsin, the loop axis remains integral and attached to the axis of the chromosome from which it originates. Callan and MacGregor[4] have demonstrated for the first time that deoxyribonuclease induces a fragmentation of the loop axis and chromosome axis, which is conclusive evidence that deoxyribonucleic acid exists not only in the main axis of the chromosome but also in the lateral loops.

Colchicine has long been known as a spindle inhibitor and mitotic poison. We have found that colchicine elicits a change in the morphology of lampbrush chromosomes in *Triturus viridescens*.

The chromosomes were isolated in a 0·59 per cent sodium chloride solution from nuclei of oocytes. The colchicine was dissolved in the same saline used for isolating the chromosomes. Colchicine was found to be effective at a concentration of 50 mgm./cm.³. Controls were run using the saline solution only. The preparations were then examined in an unfixed condition in specially constructed slides using an inverted phase-contrast microscope as proposed by

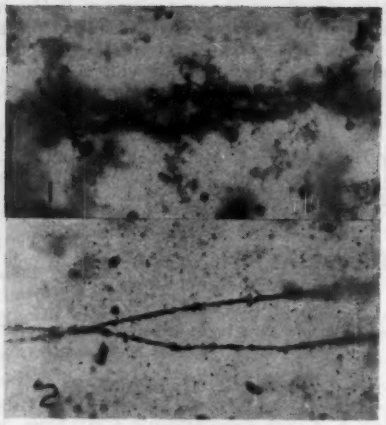

Fig. 1. Portion of an untreated bivalent fixed and stained with iron-alum hæmatoxylin showing intact loops. Fig. 2. Portion of a colchicine-treated bivalent fixed and stained with iron-alum hæmatoxylin. (× 1,000)

Gall[1]. Similar colchicine-treated and control preparations were made and fixed in formaldehyde vapour for 15 min. After fixation the slides were placed in 5 per cent formalin for 2–3 min. and stained with aceto-orcein or iron-alum hæmatoxylin. They were then placed in absolute alcohol to remove the excess stain, and the depression was filled with immersion oil and a coverslip applied to render the preparations permanent. These slides were compared with the unfixed preparations examined with the phase-contrast microscope. In both cases the results were identical.

It was found that while colchicine caused no disruption in the linear integrity of the chromosomes, there was a complete absence of loops along the entire length of the chromosomes (Figs. 2 and 4) except for the giant loops which remained. The control slides showed no absence of lateral loops (Figs. 1 and 3). Chromomeres extend along the entire axis of normal lampbrush chromosomes and render the axis cylinder of uneven diameter. In the chromosomes treated with colchicine it was noted that the axis is more uniform in diameter than in the controls and that the chromomeres are closer to one another than normally. This may be caused by a contraction of the chromosome following colchicine treatment. Most of the early experimenters with colchicine thought that the extra contraction of the chromosomes following treatment with the alkaloid drug resulted from the absence of a functioning spindle and was not an effect of a direct action on the chromosomes. However, Ostergren[5] claimed that since the extra chromosome contraction is present in prophase nuclei, it cannot be entirely due to a suppressed spindle or prolonged metaphase. This seems to be also the situation with the colchicine-treated lampbrush chromosomes for they are prophase chromosomes (diplotene).

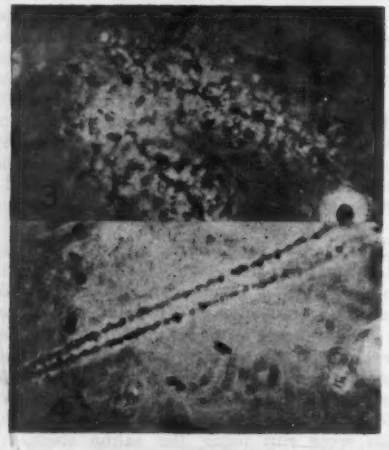

Fig. 3. Phase-contrast photograph of untreated bivalent (unfixed). Note presence of lateral loops. Fig. 4. Phase-contrast photograph of bivalent after colchicine treatment (unfixed). Note absence of lateral loops and intact axis. (× 1,000)

There are two pieces of evidence indicating that the main axis of the loop is not destroyed either along its length or at its point of origin with the axis of the chromosome. Since the interchromomeric connexions on the axis of the chromosome are not disrupted following treatment with colchicine and since there is an apparent contraction of the chromosome, it would seem that the loop axes must also contract, for they are continuous with the interchromomeric strands[3]. Also, while the loops are absent after treatment, the giant loops, when observed, are always attached to their point of origin although they do not show their usual extension into the saline; rather they appear to be drawn closer to the axis of the chromosome.

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Induction of Structural Chromosome Changes by Visible Light

It has been known since the beginning of this century that visible light is able to induce inhibitory and lethal effects on living organisms when oxygen and some sensitizing substance (which absorbs the light) are present. This phenomenon has been called 'photodynamic action'. The biological effects are believed to be due mainly to a photosensitized oxidation of organic material[1]. The fact that mutations can be induced photodynamically in micro-organisms has been shown by Döring[2] and Kaplan[3–5]. Previous studies have failed to demonstrate the production of structural changes in chromosomes among the effects induced in plant root-tips by visible light in the presence of some sensitizing substance[6,7]. The dyes used in these studies, eosin and neutral red, have no particular affinity for the cell nucleus. It seems reasonable to assume that in order to induce changes in the genetic material the light has to be absorbed by dye molecules present inside the cell nucleus. Therefore, acridine orange, which, like a number of other acridine derivatives, has a high affinity for nucleic acids[8,9], was chosen as the sensitizing substance in the present study of the effect of visible light on chromosome structure in the root-tip cells of the broad bean, *Vicia faba*.

Table 1. The Frequencies of Chromosomal Aberrations produced at Various Oxygen Tensions by Visible Light in Bean Root Tips Pretreated with Acridine Orange. Roots Illuminated from One Side Only. *p*H of *M*/150 Buffer Solution = 5·8

Duration of illumination (min.)	Pretreatment with acridine orange (+ or −)	Concentration of oxygen in the gas phase (per cent)	Number of metaphases analysed	Abnormal metaphases (per cent)	Aberrations/100 cells		
					I Isolocus breaks	II Exchanges	I + II
90	−	100	100	0	0	0	0
0	+	100	100	1	1	0	1
45	+	0	100	0	0	0	0
45	+	1	100	1	1	0	1
45	+	20	100	3	4	0	4
45	+	100	300	17	19	5	24
60	+	100	100	28	32	8	40

In the absence of light, concentrations of acridine orange less than 10^{-5} *M* proved to be non-toxic to the roots. In the presence of light, a strong toxic effect was obtained by concentrations of acridine orange greater than 10^{-6} *M*. This toxic effect was to a large extent eliminated by the experimental procedure finally adopted. When the bean seedlings had developed lateral roots, 0·3–1 cm. long, they were transferred to solutions of acridine orange made up of 3·5–5 × 10^{-6} *M*/l. acridine orange in tap water. In these solutions, the seedlings were allowed to grow in the absence of light for about 20 hr. Before the seedlings were exposed to light, excess dye was washed out by keeping the roots immersed in tap water for 2–3 hr. During the illumination period, the seedlings were in 'Lucite' vessels with their roots immersed in *M*/150 phosphate buffer solutions. The 'Lucite' vessels were the same as those which had been used previously in X-ray experiments. They have been described in detail elsewhere[10]. The different gas mixtures were introduced into the vessels through fritted glass filters. Oxygen-free nitrogen was obtained by passing tank nitrogen (containing 0·06 per cent oxygen) over active copper in a Meyer–Ronge column[11]. When the roots were exposed to light in the presence of a respiratory inhibitor, the seedlings were kept under anaerobic conditions for 10 min. before an oxygen-free solution of the inhibitor was introduced into the vessel. During the treatment, the desired gas or gas mixture was bubbled through the solution. The light sources were Philips 'Attralux' lamps, type 13378*E*/44, 24 V., 150 W. To prevent a marked rise of the temperature of the solution surrounding the roots, the 'Lucite' vessels were immersed in running tap water during the period of illumination. Between the source of light and the roots were 2·5 cm. air, 0·2 cm. glass, 13·5 cm. water and 1 cm. 'Lucite'. When the seedlings were illuminated from one side only, the temperature of the solution inside the 'Lucite' vessels was stable at 15° C.; when the seedlings were illuminated from two sides, the temperature varied between 15 and 18° C. In most experiments the seedings were kept, after the illumination, with their roots immersed in tap water at 20° C. in the absence of light for 22 hr. Before fixation, the roots were treated with 0·05 per cent colchicine for 4 hr. at 20° C. in the dark. The roots were fixed in alcohol–acetic acid, 3 : 1, and the slides prepared as permanent Feulgen-squashes.

Table 1 shows that structural chromosome changes can be produced by visible light in root-tips pretreated with acridine orange. However, a marked effect is obtained only when the gas bubbled through the solution contains more than 20 per cent oxygen. In the absence of either acridine orange or light, no significant effect is produced. Other experiments have shown that no aberrations seem to appear during the first 10 hr. after the treatment. In that respect, the photodynamically induced aberrations are similar to those induced by radiomimetic chemicals such as di-(2.3-epoxypropyl)ether[12], potassium cyanide[13], and tert. butylhydroperoxide[14]. In contrast to the radiomimetic chemicals mentioned, X-rays seem to be most effective in cells which enter mitosis within 8 hr. after the irradiation[12].

The induction of structural chromosome changes by visible light requires the presence of both oxygen and a sensitizing substance and appears, thus, to be a typical photodynamic effect. As a result of a photosensitized oxidation, organic peroxides may be formed.

Table 2. The Effect of 'Cupferron' on the Frequencies of Chromosomal Aberrations produced by Visible Light in Bean Root-Tips in the Presence of Acridine Orange. Roots in Experiments I–III illuminated from One Side; Roots in Experiments Nos. IV–V illuminated from Two Sides. *p*H of *M*/150 Buffer Solution = 5·8. After Each Treatment, 100 Cells were Analysed

Experiment No.	Duration of illumination (min.)	Pretreatment with acridine orange (+ or −)	Concentration of oxygen in the gas phase (per cent)	Treatment with 400 μM/l. 'Cupferron' (+ or −)	Abnormal metaphases (per cent)	Aberrations/100 cells		
						I Isolocus breaks	II Exchanges	I + II
I*a*	45	+	0	+	33	33	19	52
b	45	+	1	+	30	28	8	36
c	45	+	20	+	9	7	2	9
d	45	+	100	+	21	13	6	19
II*a*	45	+	0	+	50	57	28	85
b	0	+	0	+	0	0	0	0
III*a*	45	+	0	+	44	82	42	124
b	45	+	10	+	9	5	5	10
IV*a*	30	+	0	−	0	0	0	0
b	30	−	0	+	3	3	0	3
c	0	+	0	+	5	4	1	5
d	30	+	0	+	38	39	24	63
e	30	+	1	+	40	37	26	63
V*a*	30	−	1	+	8	4	4	8
b	30	+	1	+	53	51	52	103
c	0	−	1	+	1	1	0	1
d	0	+	1	+	0	0	0	0

Schenck[15,16] has reported light-induced *in vitro* synthesis of a considerable number of different organic peroxides in the presence of oxygen and some sensitizing substance. Since organic peroxides are known to produce chromosomal aberrations in bean roots[13,17], it seems possible that such compounds are involved in the photodynamic induction of structural chromosome changes.

A radiomimetic effect of acridine orange has been reported by D'Amato[18], working with onion root-tips as experimental material. Since D'Amato performed his experiments "in the ordinary conditions of diurnal illumination", it seems possible that in his experiments, too, the radiomimetic effect of acridine orange was due to its ability to act as a photosensitizing substance. In the present study, acridine orange was inactive in the absence of light.

Because of the respiratory activity of the cells, the oxygen concentration is likely to be considerably lower in the central parts of an organized tissue such as a bean root than in the solution surrounding the tissue. The existence of such an oxygen gradient in respiring tissues explains why the X-ray sensitivity of bean roots is influenced by much lower concentrations of oxygen in the presence, than in the absence, of a respiratory inhibitor[10,19].

In order to find out if structural changes in chromosomes can be induced photodynamically at lower oxygen concentrations when respiration is inhibited, a number of experiments were performed with cupferron (the ammonium salt of N-nitroso phenylhydroxylamine) as a respiratory inhibitor. The results appear in Table 2. In the 45-min. experiments, the cupferron treatments were of the same duration as the period of illumination. When the roots were illuminated for 30 min. only, the duration of the cupferron treatments was 40 min. Previous experiments have shown that cupferron is a radiomimetic agent in the presence of oxygen[12,20]. However, in order to obtain a marked radiomimetic effect, it is necessary to have higher concentrations of cupferron and higher treatment temperatures as well as longer periods of treatment than those used in the present study (400 μM; 15–18° C.; 40–45 min.).

Table 2 shows that in the absence of either light or oxygen there is no marked effect of cupferron on roots which have not been pre-treated with acridine orange (IV*b*, V*c*). There is some evidence that the radiomimetic effect of cupferron in the presence of oxygen is somewhat increased by light (V*a* and unpublished results). In the absence of light, no marked effect is obtained with cupferron on roots pre-treated with acridine orange (II*b*, IV*c*, V*d*). However, when roots pre-treated with acridine orange were illuminated in the presence of cupferron but in the absence of oxygen (oxygen-free nitrogen bubbled through the solution), the magnitude of the effect obtained was of the same order as that produced by 100 r. of X-rays in air, which is close to the upper limit of what can be conveniently scored (I*a*, II*a*, III*a*, IV*d*). When oxygen was introduced into the system the effect decreased. At 1 per cent oxygen in the gas phase, the effect was still about the same as that obtained in the absence of oxygen (I*b*, IV*e*), but when the oxygen concentration was 20 per cent or more, the effect was no stronger than that obtained in the absence of cupferron (Table 1, Table 2 : I*c*, I*d*).

The fact that the highest frequency of aberrations was obtained when oxygen-free nitrogen is bubbled through the solution suggests that in the presence of cupferron there is some other mechanism than that involving oxygen by which light energy absorbed by acridine orange can be used for the production of chromosomal aberrations. This would mean that, in contrast to the results summarized in Table 1, those obtained in the cupferron experiments are not explainable by the peroxide hypothesis.

The investigation was supported by a grant from the Swedish Natural Science Research Council.

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ANIMAL PHYSIOLOGY

Hyperglobulinæmic Thrombo-Hæmorrhagic Diathesis

In reviewing the literature of the hyperglobulinæmias one is struck by the frequency of the reports of a concomitant hæmorrhagic diathesis. In a survey by us of more than a thousand cases of macroglobulinæmia, cryoglobulinæmia, visceral leishmaniasis and miscellaneous hyperglobulinæmias, a hæmorrhagic diathesis was reported in 63–94 per cent of the cases in each category. These observations suggest that purpura is a general phenomenon in the presence of increased plasma globulins.

Thromboses, in addition to hæmorrhages, were reported in 3–21 per cent of the cases. This coincidence of thromboses and hæmorrhages is of sufficient moment to warrant its consideration as a clinical entity for which the name hyperglobulinæmic thrombo-hæmorrhatic diathesis is suggested. We have also observed both thromboses and hæmorrhages in a group of patients reported elsewhere[1,2].

An explanation of this observation is suggested by the experimental studies made in this laboratory which have shown that some globulins have the ability to combine with clotting factors. The hypothesis is proposed that in a variety of clinical conditions γ-globulins are produced which acquire the ability to combine with clotting factors. When such associations occur, the clotting factors are withdrawn from active participation in clotting and hæmorrhages ensue. When such combinations dissociate, large amounts of clotting factors are released suddenly into the blood-stream and the

situation becomes thrombotic. When both association and dissociation are occurring, the clinical picture would include both hæmorrhages and thromboses, that is, a thrombo-hæmorrhagic diathesis.

8 patients with euglobulin have been studied; 2 with macroglobulinæmia, 2 with multiple myeloma, 1 with alcoholic liver cirrhosis, 1 with rheumatoid arthritis and 2 with myocardial infarctions. One of the myeloma cases had a cryo-fibrinogen-globulin complex as well as the euglobulin.

The following behaviour characteristics of the unusual euglobulins studied are significant.

(1) These proteins have the ability to complex with, and co-precipitate, clotting factors. Precipitation of the euglobulin from the patient's plasma, or from normal plasma to which it was added, reduced the concentration of clotting factors remaining in the plasma. These clotting factors were demonstrable in the solution of the precipitated euglobulin.

(2) The euglobulins can combine with and remove from the plasma active accelerin, its precursor proaccelerin, prothrombin and convertin. The amounts and proportions of the clotting factors involved vary from case to case.

(3) Some results suggest that this association of euglobulin with clotting factors occurs *in vivo* as well as on precipitation of the euglobulin. It was frequently observed that the sums of the accelerin and proaccelerin concentrations in the solution of the euglobulin and in the plasma freed of euglobulin were greater than the concentrations in the whole plasma. This phenomenon was also seen when precipitation of the euglobulin did not reduce the plasma accelerin- or proaccelerin-level, but when appreciable amounts of these factors were found in the euglobulin. In one case, a high level of prothrombin activity was demonstrable in the euglobulin precipitated from serum when the residual serum prothrombin was nil. In another case, more accelerin, proaccelerin and convertin were measurable in serum euglobulin and euglobulin-free serum than in the whole serum. The clotting factors present in excess of the measurable plasma- or serum-levels represent the amount which was held *in vivo* by the euglobulin.

(4) The possibility of *in vivo* inhibition of clotting factors by euglobulin has been suggested by instances of increased prothrombin, convertin and proaccelerin after the removal of euglobulin.

The clotting abnormalities are usually, but not always, associated with increased total plasma proteins. 2 of the 8 patients studied had normal total protein-levels; all but one had increased γ-globulins. Comparison of the quantities of euglobulin present with the amount of clotting factor activity coprecipitated indicates that euglobulin of the order of 100 mgm. per cent can contain as much as 600 per cent of proaccelerin.

A globulin which complexed with fibrinogen to form a cold precipitable complex was first reported in one of these cases of multiple myeloma[1]. This observation has been confirmed by Firkin[3] in a case of essential cryoglobulinæmia. On the basis of the concept presented here, dicumarol was used by Domz and Feigin[4] in a case of essential cryoglobulinæmia with Raynaud's phenomenon, cyanosis and necrosis of the fingers. There was an immediate response to the therapy with complete relief of the pain within 48 hr., followed by rapid healing of the fingers.

This work was aided by grants from the Leukemia Research Foundation, Inc., and the Donate Once Club of North American Aviation, Inc., Los Angeles, California, and grant *H-2668 C* from the National Heart Institute, Department of Health, Education and Welfare, Bethesda, Maryland.

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Recurrent Inhibition in Cerebral Cortex

RECURRENT inhibition via interneurones (Renshaw cells) was recently invoked by Brooks and Wilson[1] to account for changes in monosynaptic spinal reflexes following antidromic activation. This mechanism, which confines stretch reflexes to their paths of afferent origin, operates through a cholinergic synapse between the motoneurone axon collateral and the Renshaw cell[2], which liberates an unknown inhibitory transmitter. Presumably the same mechanism functions with respect to disynaptic pathways through the cord. The purpose of this communication is to describe an analogous system in the cerebral cortex of dogs, operated under ether and immobilized by succinylcholine.

During experiments on the interaction between antidromic volleys in the medullary pyramids[3] recorded with cortical microelectrodes, and impulses from the thalamic nucleus ventralis lateralis[4], antidromic inhibition of cortical re-excitation[5] and directly excited cortical activity were noted[6]. In the present experiments the pathway from the thalamus to the corticospinal tract via the cortical projection of the nucleus ventralis anterior was used as a test. This has been presumed to be disynaptic with one interposed neurone. The antidromic volley was delivered via one bundle of corticospinal fibres, separated from the pyramid. The ventralis anterior was stimulated bipolarly, and the responses recorded in the remainder of the medullary pyramid (Fig. 1, *A* and *B*). It was found that the anticholinergic drug, dihydro-beta-erythroidine hydrobromide, reduced the magnitude of antidromically elicited inhibition in this 3-neurone arc. The drug was given in the ipsilateral carotid artery in amounts of 0·5 mgm./kgm. following isolation of the internal carotid circulation. Antidromic inhibition, as judged both by the decreased rate of discharge in the corticospinal tract to pyramidal stimuli of increasing frequency and by the amount of hyperpolarization of cortical neurones recorded with intracellular electrodes[3], was increased by 20–30 μgm. of acetylcholine chloride, and increased still further by 0·2–0·5 mgm./kgm. of eserine sulphate, given intra-arterially (Fig. 1, *C*). With increasing frequency of stimulation of the medullary pyramid the probability of firing of single gigantopyramidal neurones dropped, according to a parabolic function, over the frequency-range of 30–40 c./s. The same effect was obtained from bipolar stimulation of the cortex at a depth of 1·0–1·3 mm.

Further, the inflexion in the rising phase of intracellular pyramidal neurone spikes was increased by antidromic and deep cortical stimulation. This represents hyperpolarization.

Since the Renshaw mechanism in the cortex cannot be substantiated without physiological demonstration of the inhibitory interneurones, the cortical layers were systematically mapped during the above-mentioned pyramidal hyperpolarization of cells. Rapidly discharging units were found at depths corresponding to cortical layers III and IV in the dog 'motor' and 'premotor' areas (Fig. 1, *D*). These units were active during hyperpolarization of primary neurones. Further pharmacological studies showed that the hypothetical inhibitory synapse was blocked by picrotoxin, strychnine and tetanus toxin, the latter two drugs having been used in the spinal cord by Eccles with similar results[2]. A detailed description of this and related findings is in preparation.

Histological evidence for a cortical Renshaw system was also sought. Cajal demonstrated the endings of pyramidal neurone collaterals on short-axon neurones, and functional evidence for their existence is abundant[5]. The existence of star-cell axons (assumed to be interneurones) upon the apical dendrite of pyramidal cells in the same or next lower layer has also been shown (Fig. 2, *A*). Recent work[7] has indicated that much, if not all, of the activity at axo-dendritic synapses relates to the creation of long-standing hyper- or de-polarization of the apical dendrites. It has also been suggested[8] that such changes are due to the activity of excitatory or inhibitory interneurones, although no physiological or anatomical arrangement of these has been put forth which would account accurately for most of the results concerning cortical activity.

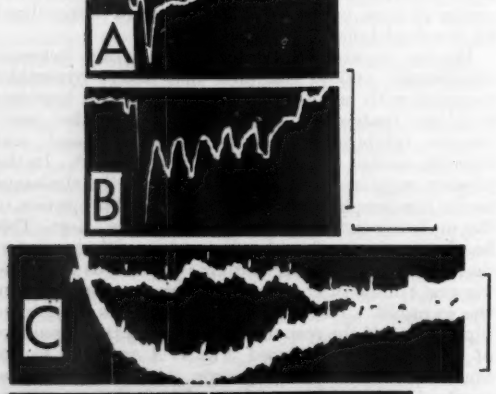

Fig. 1. *A*, Response recorded in one bundle of medullary pyramid fibres following stimulation of remainder of pyramid and stimulation of the ventralis anterior. *B*, Same response after 0·5 mgm./kgm. dihydro-beta-erythroidine hydrobromide. Note increased amplitude of surface positive and oscillating (interneuronal) responses. For *A* and *B* time mark is 8 msec. *C*, Potentials generated in a gigantopyramidal neurone (responding to pyramidal stimulation) by an antidromic volley (40 c./s.) in corticospinal fibres recorded between an intracellular electrode and an indifferent point. Horizontal superposed traces were obtained before antidromic stimulation. Intracellular negativity downward in this and following record. The latency of this hyperpolarization is 0·5–2·0 msec. following activity of cells in deeper layers. Msec. time marks. Potential calibration, 5 mV. *D*, Discharges of a cortical inhibitory interneurone, recorded intracellularly at a depth of 1·1 mm. in dog motor cortex, following antidromic volley in corticospinal tract. Time mark, 20 msec., potential calibration, 30 mV.

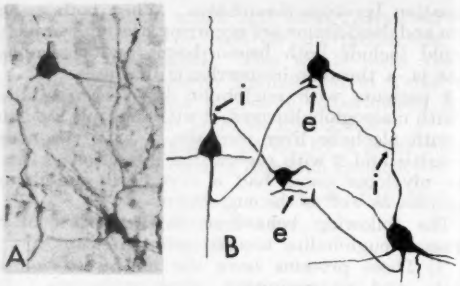

Fig. 2. *A*, Photomicrograph of cat visual cortex (by courtesy of Dr. E. Ramon-Moliner, Montreal Neurological Institute), modified Golgi Cox stain, showing ending of star-cell axon in layer IV upon apical dendrite of pyramidal neurone in layer V. Arrows trace course of axon. (× 125). *B*, postulated anatomical arrangement for a cortical recurrent inhibitory system. Inhibitory endings, *i*; excitatory (cholinergic) endings, *e*.

It is not postulated that this inhibitory mechanism, which had been suggested by Phillips[3] and others, is the only, or even the most widely active, means for cortical inhibition. However, these results, in addition to a large number of supporting observations which are less rigorous, make its existence most likely. Its proposed structure and operation are outlined semidiagrammatically in Fig. 2, *B*. Inhibitory endings are thought to exist primarily on neighbouring or remote neurones, rather than on the neurone the collateral of which activates the inhibitory cell. Cells firing to afferent impulses would excite neighbouring cells until the inhibitory mechanism reduced the activity multiplication factor to one. Firing cells inhibit neighbours, and are thereby protected from inhibition. In this manner a small group of cells with inhibitory interconnexions could maintain a relatively constant firing-rate without necessitating reverberation or re-entry circuits, which might nevertheless exist. It is suggested further that the hyperpolarization exerted by inhibitory interneurones has only a partial effect upon, but does not alone control, the basal firing rhythm[6] of primary cortical neurones. Electrocorticographical findings which support this concept have been obtained[9] and a similar arrangement based on theoretical considerations has been independently described by Milner[10].

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Synthesis of Dextran Sulphate labelled with Carbon-14 and Tracer Experiments in the Rat

PREVIOUS experiments[1,2] with the heparinoid anticoagulant, dextran sulphate, in experimental animals and man have established that between 40 and 50 per cent of a single intravenous dose of dextran sulphate of a molecular size suitable for clinical use was excreted in the urine in 48 hr.

Autoradiographs of the tissues of animals given dextran sulphate of similar molecular characteristics labelled with sulphur-35 suggested that the portion of the dose unaccounted for by urinary excretion was broken down within the body but that the ^{35}S-sulphate residue was retained in the general body pool of ester sulphate since, as with the administration of $Na_2{}^{35}SO_4$ [3], radioactivity was demonstrable in gastric mucin, skin and, to a lesser extent, in cartilage (Walton, unpublished work). This redistribution of the labelled sulphate residue rendered difficult the interpretation of the results obtained in terms of the distribution of dextran sulphate in the tissues. Accordingly, further experiments have been undertaken using dextran sulphate labelled in the dextran part with carbon-14.

^{14}C-Dextran was prepared by inoculating an aqueous buffered medium containing yeast extract and ^{14}C-sucrose (3·76 gm., 3·3 mc.) with *Leuconostoc mesenteroides* and incubating the mixture for 3 days at 25° C. ^{14}C-Dextran and protein were precipitated with ethanol. The precipitate was redissolved and freed from protein by treatment with trichloracetic acid yielding 1·162 gm. ^{14}C-dextran with a specific radioactivity of 22·39 mc./mole of carbon.

The ^{14}C-dextran so obtained was partially hydrolysed with $N/1$ sulphuric acid and fractionated by the addition of successive increments of acetone. A fraction (232 mgm.) of viscosity comparable to that used for the preparation of clinical dextran sulphate was selected for sulphation by treatment with chlorosulphonic acid in pyridine as previously described[4].

The ^{14}C-dextran sulphate (413 mgm.) (found: C, 20·40; H, 2·15; S, 16·85. $[C_6H_{8\cdot16}O_5\ (SO_3Na)_{1\cdot84}]_n$ requires C, 20·59; H, 2·35; S, 16·86 per cent) had a specific radioactivity of 22·39 mc./mole carbon or 0·45 μc./mgm. and an anticoagulant activity of 13 units/mgm. Paper chromatography revealed results similar to those obtained with the dextran sulphate previously employed[2].

A male albino rat weighing 273 gm. was injected intravenously via the tail-vein with a solution of ^{14}C-dextran sulphate (5 mgm., that is, 2·25 μc. and dose equivalent to 18·3 mgm./kgm./body-weight) in saline and placed immediately in a closed-circuit apparatus[5], allowing collection of the respired air. The rat was maintained thus for 48 hr., being allowed access to food and water *ad libitum*. The expired carbon dioxide was collected in 3 *N* sodium hydroxide and converted into barium carbonate. Aliquots were used for the determination of specific radioactivity.

At the end of the experimental period the animal was killed by a blow on the head, various organs were removed, weighed and portions homogenized by grinding under liquid air. Other portions were submitted to histological examination which confirmed that the injected material, like previously tested examples of dextran sulphate for clinical use[6], was not segregated in reticulo-endothelial cells.

Table 1. LABELLED CARBON CONTENTS OF RESPIRED CARBON DIOXIDE AND OF TISSUES OF RAT FOLLOWING INJECTION OF 5 MGM. (2·25 μC.) OF ^{14}C-DEXTRAN SULPHATE IN EXPERIMENT LASTING 48 HR.

Source	Weight (gm.)	Carbon content (per cent)	Specific radio-activity (μc./mole carbon)	Total radio-activity (μc.)	Concentration of injected radio-activity (per cent)
Carbon dioxide respired	125·674	6·085	0·13	0·08	3·55
Liver	13·366	13·35	1·19	0·18	8·0
Spleen	0·650	9·15	1·00	0·005	0·22
Lungs	2·810	9·08	0·19	0·004	0·18
Kidneys	2·423	23·20	1·68	0·08	3·55
Muscle (sample)	1·120	9·73	0·17	—	—
Total musculature	123·94*	—	—	0·17	7·56
Bone (femur)	0·86	5·62	0·15	—	—
Whole skeleton	14·80*	—	—	0·01	0·44

Total radioactivity accounted for: 23·50 per cent of dose.
* Average figure derived from published data, ref. 10.

^{14}C-Dextran and ^{14}C-dextran sulphate were burned in a stream of oxygen free of carbon dioxide, and aliquot parts of the homogenized tissues were treated with boiling chromic acid combustion fluid[7]. The carbon dioxide produced in each case was converted into barium carbonate and the radioactivity determined by the infinitely thick disk method[7–9] using an end-window counter and a sample of poly-(^{14}C-methyl) methacrylate supplied by the Radiochemical Centre, Amersham, as a standard source for barium ^{14}C-carbonate. The results tabulated are corrected for background and paralysis time of the counting equipment.

Excretion of carbon dioxide labelled with carbon-14 in the expired air indicated complete oxidation of a portion of the administered ^{14}C-dextran sulphate. The rate at which this occurred appeared to be somewhat slower than the rate of excretion of labelled carbon dioxide from ^{14}C-dextran in rats since 3·55 per cent of the injected dose of ^{14}C-dextran sulphate was accounted for after 48 hr. in the present experiment as compared with 8–10 per cent of ^{14}C-dextran[11] in the same period. The radioactivity of the expired air together with that found in the organs examined accounted for 23·50 per cent of the dose administered. Assuming urinary excretion of a further 40–50 per cent in the first 48 hr. as previously found[1,2] about 30 per cent remained unaccounted for and presumably was distributed in the body fluids and tissues not sampled.

The distribution of radioactivity in the tissues suggested that the major sites of retention (and therefore possibly of metabolism) of the material were in the liver and in muscle (8 per cent each), as has also been found for ^{14}C-dextran[11]. High retention in the liver has previously been found for other labelled polysaccharide sulphates (namely, 7·2 per cent for cellulose ^{35}S-sulphate[12] and 9·0 per cent for one preparation of low molecular weight xylan ^{35}S-sulphate[13]). The significance of the relatively high radioactivity found in the kidneys in the present experiment (3·55 per cent) is less clear since this might be accounted for partly by this organ being the one chiefly concerned in the excretion of dextran sulphate[2] and therefore probably containing ^{14}C-dextran sulphate in process of excretion in the urine.

The sample of dextran sulphate used for the experiments described underwent decomposition

before further biological experiments could be carried out. It seems likely that decomposition was initiated by self-irradiation and continued autocatalytically under acidic conditions. Details of this work will be published elsewhere.

We thank Profs. M. Stacey and J. R. Squire for their interest and for providing facilities. We are indebted to Prof. E. J. Bourne and Dr. C. R. Ricketts for helpful discussions throughout the work, and to Dr. W. F. R. Pover for advice and the loan of the closed-circuit apparatus used. We also acknowledge gratefully generous financial assistance from Messrs. Glaxo Laboratories, Ltd., for this work.

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Passive Antibody Decay in Thyroidectomized Rabbits

In the course of an investigation of the immune response of rabbits exposed to a low environmental temperature (− 15° C.) it was noted that the decay-rate of passively administered homologous antibody was increased[1]. Reference has been made to the fact that thyroxin-treated rabbits also exhibit an increase in passive antibody decay[2]. The fact that an animal metabolizes protein more rapidly under conditions of cold stress or when treated with thyroxine leads one, *a priori*, to consider more closely the influence of the thyroid on the immune response under cold stress. The following preliminary investigation was therefore undertaken to determine the effect of surgical thyroidectomy on the rate of decay of passively administered homologous antibody.

Adult male rabbits weighing 2·5–3·0 kgm. were used in this study. Five were surgically thyroidectomized and allowed to recuperate for 2–3 weeks before being injected with antibody, at which time their metabolic rate was approximately 75 per cent of normal. Ten untreated rabbits were used as controls.

The antibody used in this study was homologous γ-globulin prepared from high-titre anti-bovine serum albumin rabbit serum by one-third saturation with ammonium sulphate at *p*H 7·8. The γ-globulin so obtained was reprecipitated twice, dissolved in 1 per cent pyrogen-free sodium chloride, and the residual ammonium sulphate removed by dialysis against 1 per cent sodium chloride. Each animal was injected intravenously with 15 ml. of the γ-globulin solution, which contained approximately 170 mgm. of precipitable antibody protein. The animals were bled at intervals and the circulating antibody concentration estimated by the quantitative micro-precipitin analyses by a modification of the method of Lanni *et al.*[3]. The results were plotted semi-logarithmically as the percentage of the injected dose remaining in the circulation versus time (Fig. 1). The slope of the linear portion of the curve (assumed to represent steady-state loss of antibody) was calculated by the method of least squares, extrapolated back to zero time, and half-life values calculated from that point.

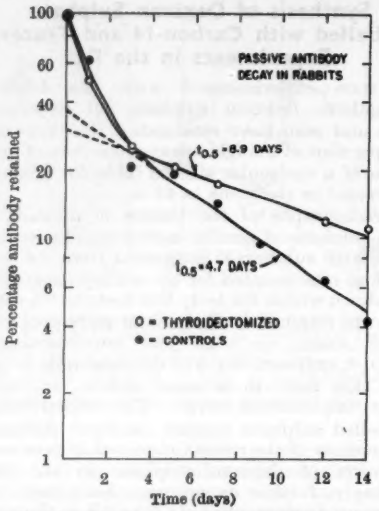

Fig. 1. Semi-logarithmic plot of percentage of injected antibody remaining in circulation versus time in days

The half-life of passively administered homologous antibody in the thyroidectomized rabbits was 8·9 ± 0·4 days compared to 4·7 ± 0·2 days for the untreated controls.

Previous work by others has indicated that thyroxin decreases and propylthiouracil increases antitoxin production in rabbits, but has the opposite effect in guinea pigs[4]. This species difference is attributed in part to a thyroxine-induced adrenocortical hyperactivity, which may have a greater effect in depressing antibody production in the 'cortisone-sensitive' rabbit than in the 'cortisone-resistant' guinea pig. The significance of these results and our own in relation to the immune response under stress conditions raises the question as to whether a change in circulating antibody-level would be due primarily to an alteration in the antibody-forming mechanisms, or would be due to the effect of these conditions on the mechanisms responsible for antibody decay. If the changes in antibody decay are considered as being superimposed on an essentially normal rate of antibody production, the net result would be an apparent decrease in the immune response of thyroxin-treated rabbits and an apparent increase in the immune response of hypothyroid rabbits. If, on the other hand, there is also

an alteration in the rate of antibody production, then the net result would be either an accentuation of the immune response, if antibody production was affected in the opposite direction, or perhaps no observable difference, if a change in antibody decay was offset by a change in antibody production in the same direction, that is, an increase in antibody decay compensated by an increase in antibody production. Further study on the influence of the thyroid on the immune response is indicated, and experiments on active antibody production are now in progress.

This investigation was supported in part by the Office of Naval Research, *NR*102–392, and in part by the National Institutes of Health, U.S. Public Health Service.

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Balance Trials with Magnesium-28 in Sheep

FÆCAL magnesium comprises two fractions, an endogenous fraction originating from the body and excreted into the gut and an exogenous fraction representing unabsorbed dietary magnesium. Once the relative proportions of these two fractions are known, it is possible to calculate both the endogenous fæcal magnesium and the true availability of dietary magnesium. A method for determining these proportions would seem to be the comparative balance technique[1], since this could be adapted for magnesium-28 provided the quantity of this isotope in a single dose was sufficient for accurate determination of the total eliminated in the fæces after either oral or intravenous administration. As the cost of magnesium-28 is very high the size of dose for economic reasons must be small, but this communication describes experiments which would appear to be satisfactory from both points of view.

Cyclotron-produced 'carrier-free' magnesium-28 was used, and initially the doses contained 80 μc., but after chemical separation and transit, only about 30–40 μc. remained for administration into the sheep. The cost of each dose was £30.

Trials were carried out with one sheep, an adult North Country Cheviot wether, which received a constant diet of hay supplying 0·77 gm. of magnesium a day throughout the experiment. Single doses of magnesium-28 were given at 8.40 a.m., either into the rumen through a fistula, or into the jugular vein by means of a nylon catheter. The fæces and urine were collected twice daily at 8.40 a.m. and 4.40 p.m. and their radioactivity determined in a modified ring counter[2].

After ruminal administration it was found that magnesium-28 could be followed in the fæces for 5 days only. Nevertheless, it was possible to calculate the magnesium-28 still to be eliminated in the fæces since the ratio of magnesium-28 to dry matter in the fæces declined exponentially after reaching a peak on the second day after administration. This can be expressed by the following equation:

$$R = 0{\cdot}304 \exp(-0{\cdot}0306t)$$

where R is magnesium-28 recovered in fæces/magnesium-28 administered × 100/fæcal dry matter and t is time after administration (hr.).

Of the original dose, 62·6 per cent was recovered from the fæces within the period 2–5 days after administration, and it was calculated by integration of the above formula that a further 3·4 per cent would be eliminated by the same route after 5 days. These, together with the 13·2 per cent passed out on the first day, make a total of 79·2 per cent of the ruminal dose eliminated in the fæces. In the first 5 days, 0·07 per cent was excreted in the urine. Over the same period the fæcal non-radioactive magnesium represented 100·8 per cent of the dietary intake.

Following intravenous injection, urinary magnesium-28 could be followed for 5 days and fæcal magnesium-28 for 4 days 8 hr., and over this period 11·9 and 19·4 per cent of the given dose were excreted by the separate routes. The value for urinary magnesium-28 is much greater than those reported for calcium-45 in cattle[3], suggesting that the urinary route of excretion is more important for magnesium than it is for calcium.

The calculated values for the endogenous fæcal magnesium and the availability to the sheep of the magnesium present in hay were 205 mgm./day and 25·8 per cent respectively. These values are in good agreement with those determined for similar sheep by Field *et al.*[4] using indirect methods.

The evidence presented here shows that the true availability of dietary magnesium can be determined with magnesium-28, but its use will be limited by its high cost and its short half-life, which results in a severe reduction of its radioactivity in transit.

My thanks are due to Dr. J. R. Greening and Mr. P. Tothill, Department of Medical Physics, University of Edinburgh, for their valuable help.

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Metabolism of Benzene Hexachloride by Resistant Houseflies *Musca domestica*

OUR previous work on the metabolism of isomers of benzene hexachloride by a resistant strain of houseflies showed that the α- and γ-isomers are rapidly converted to water-soluble metabolites[1–3], and in the course of the reaction chloride ions are formed in the proportion of four or more per molecule of benzene hexachloride metabolized[4]. We have now found that alkaline hydrolysis of the metabolic products produces dichlorothiophenols.

The method of isotopic dilution was used for identifying the thiophenols, which have not yet been

isolated. The Jealotts Hill strain of flies resistant to benzene hexachloride[5] was exposed to α- or γ-benzene hexachloride labelled with carbon-14 in a closed flask for 24 hr. and then extracted with 80 per cent ethanol. To this extract was added 200 mgm. of pure unlabelled dichlorothiophenol and the mixture subjected to alkaline hydrolysis with sodium hydroxide at 100° C. for 30 min. The dichlorothiophenol was then converted to a derivative, either by oxidation with iodine to the disulphide $(Cl_2C_6H_2S)_2$ or by reaction with chloroacetic acid to the dichlorophenyl thioglycollic acid ($Cl_2C_6H_2.S.CH_2.CO_2H$). The derivative was isolated and repeatedly crystallized until the radioactivity measured in a flow-type proportional counter could no longer be reduced, even with change of crystallizing solvent.

Each of the six dichlorothiophenols was tested in this way with the results shown in Table 1.

Table 1. Dichlorothiophenols produced by Alkaline Hydrolysis of Metabolites of Benzene Hexachloride from Houseflies Resistant to γ-Benzene Hexachloride

Position of chlorine atoms	Percentage of total water-soluble benzene hexachloride metabolites	
	α-Benzene hexachloride	γ-Benzene hexachloride
2 : 3-	2*	< 1*
2 : 4-	20* 21†	32*
2 : 5-	21* 19†	16* 14†
2 : 6-	5*	9*
3 : 4-	19* 22*	5* 4†
3 : 5-	< 2*	< 2*

* Using thioglycollic acid derivative.
† Using disulphide derivative.

The figures show that alkaline hydrolysis of metabolites of benzene hexachloride produce dichlorothiophenol amounting to approximately 68 per cent of the water-soluble products from the α-isomer and 61 per cent from the γ-isomer. It is inferred that the metabolism of benzene hexachloride by the flies to produce water-soluble compounds involves the formation of a C—S bond. The nature of the initial metabolic product is not known ; but it is suggestive that aryl mercapturic acids produced from halogen compounds in mammalian detoxication processes[6] are converted to thiophenols by alkaline hydrolysis[7].

A scheme which would satisfactorily account for the production of dichlorothiophenols from benzene hexachloride is set out below, but it is emphasized that we have at present no evidence in support of this other than that offered above.

$$C_6H_6Cl_6 + HSR \rightarrow C_6H_6Cl_5.S.R \rightarrow C_6H_3Cl_2SH + ROH + 3HCl$$

In this reaction the nature of *R*SH is unknown, but it is possible that the compound may be reduced glutathione. This compound, which has been shown by Kearns and his colleagues[8] to be essential for the *in vitro* enzymatic conversion of DDT to its monodehydrohalogenation product DDE, we now know to be essential also for the benzene hexachloride process *in vitro*.

Following in detail the methods employed by Kearns we have been able to convert α- and γ-benzene hexachloride to water-soluble compounds *in vitro* using fly macerates, acetone powders prepared from macerated flies, and impure enzyme preparations made from fly extracts by cold fractional precipitation with ammonium sulphate. The products of the *in vitro* enzyme reactions have been shown to yield thiophenols by alkaline hydrolysis. The *in vitro* reaction did not proceed in the absence of added glutathione.

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Effect of Chloral Hydrate on Growth of Hair

Studies on the percutaneous toxicity of liquids applied as small (100μ) droplets to the guinea pig have shown that the presence of hair prevents some of the droplets from reaching the skin. Consequently, when the test liquid is applied in this droplet size, it shows less toxicity than an equivalent weight of large (400μ) droplets[1].

In percutaneous toxicity studies in the guinea pig, it is usual in this laboratory to apply the test liquid to animals 24 hr. after they have been clipped or chemically depilated. This 24-hr. period is allowed to minimize the effects on the skin of the hair-removal procedures. Although some species, such as the rabbit, show no appreciable hair growth 24 hr. after depilation, a very considerable growth occurs in the guinea pig.

The present experiment was conducted to determine whether or not this rapid regeneration of hair could be prevented. The inhibiting drug chosen for the investigation was chloral hydrate. Butcher[2], in studies on the hair cycle of the rat, reported that the hair follicles were inactivated by the subcutaneous injection of this drug. He did not mention the dosage used, or the duration of the treatment. The dosages chosen for the present experiment were 50 mgm./kgm. and 100 mgm./kgm., which are well below the hypnotic dose[3] of 250 mgm./kgm.

As test animals, 12 male and 12 female guinea pigs weighing 700–800 gm. were chosen. They were divided into three groups each with 4 males and 4 females. The animals in one group received 100 mgm./kgm. of chloral hydrate, those in another group 50 mgm./kgm. of the drug and the third was the control group. The chloral hydrate was dissolved in saline (160 mgm./c.c.) and daily injections were made subcutaneously for 14 consecutive days. On the fifteenth day, all animals were depilated with a barium sulphide paste. 24 hr. later, it was noted that the control animals all showed the usual rapid hair growth, whereas in all the animals treated with the drug the growth was inhibited to a considerable extent. No differences in effect could be noticed between the two dosage-levels, nor between male and female animals.

Several depilated animals were observed over a period of 6 days in order to study the effect of the drug on subsequent regrowth of hair. It is quite evident that the inhibiting action of the drug persists for at least 7 days after its administration has been discontinued.

The results of the present experiment indicate that, by using guinea pigs treated with chloral hydrate, the comparative percutaneous toxicity of large and small droplets of liquid chemical substances may be investigated without the interfering effect of hair.

This work was carried out in the Physiology Section, Defence Research Board of Canada, Suffield Experimental Station, Ralston, Alberta, under project No. *D*-52-89-50-15.

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Crystals of Riboflavin making up the Tapetum Lucidum in the Eye of a Lemur

The tapetum lucidum of the eye is a specialized layer lying behind, but adjacent to, the light-sensitive cells of the retina. It is specialized to form a reflecting surface so that any light not absorbed during its first passage through the light-sensitive cells is reflected back again and has a second opportunity to be absorbed. The tapetum is the basis of eye-shine in animals; it may be made up of crystals or of regularly arranged fibres[1,2]. Many fish, for example, have tapeta made of crystals of guanine, carnivores one of crystals of a complex of zinc-cysteine[3], while herbivores such as the sheep and cow have fibrous tapeta. Man and the higher apes have no tapetum; but some lemurs have a well-developed one; the brilliant yellow tapetum of *Galago monteiri* is described by Johnson[4], who says " . . . the background resembles burnished gold". Rochon-Duvigneaud[5] has found that both diurnal and nocturnal lemurs may have a tapetum. Kolmer[6] agrees with this and notes that the tapetum of *Lemur rufifrons*, a diurnal lemur, is both crystalline and yellow. Luck[7] has found that the eyes of *Galago crassicaudatus agisymbanus*, a nocturnal lemur, have a fluid vitreous body and a highly developed cellular tapetum which is brilliant gold in colour.

Through the kindness of Prof. C. P. Luck, I have examined the eyes of this lemur *Galago crassicaudatus agisymbanus*, and the evidence suggests that the tapetum is made of crystalline riboflavin.

Examination in vivo. The fundus of the eye viewed ophthalmoscopically shows a brilliant yellow-green central area with a peripheral pigmented part. With pupils dilated and in sunlight a green-yellow reflexion can be seen; this is also observable, though less marked, if ultra-violet light from a mercury arc lamp is shone into the eye, which makes it probable that the light reflected through the pupil is due at least in part to fluorescence.

Examination in vitro. The central area of the fundus in the opened eye is brilliant yellow. When the retina is removed the brilliance is more marked and is, as Johnson says, like burnished gold. Much of the yellow material can be brushed or scraped off the underlying choroid and when examined microscopically with polarized light shows flat crystalline plates of irregular size (Fig. 1). Where the plates overlap they are yellow. Using acetone as fixative, sections can be made showing crystals lying immediately behind the retinal pigment epithelium, which is devoid of pigment in the central tapetal area. The

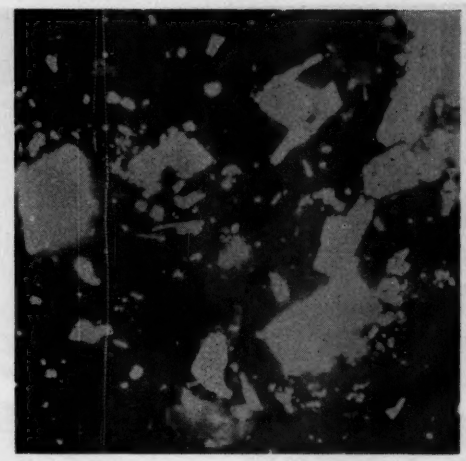

Fig. 1. Crystalline material brushed off the tapetum of *Galago crassicaudatus* and examined with polarized light

crystals were, however, irregularly arranged, totally lacking in some parts and appearing more like needles or rods than flat plates (Fig. 2); probably even acetone fixation allows some solution and rearrangement of the crystals. When examined under ultra-violet light the crystals in the section of the eye fluoresced bright yellow.

Identification of crystals as riboflavin. The yellow material either from tapetal material dried in acetone or from the tapetal scrapings was dissolved in water or 1 per cent formic acid. Such solutions are yellow and show yellow-green fluorescence. The absorption curve in 0·1 per cent formic acid showed peaks at 266 mμ, 370 mμ and 445 mμ, the peak at 266 mμ being the greatest. Light of 285 mμ, 395 mμ and 470 mμ was used to elicit fluorescence at 530–550 mμ. Both the absorption curve and the fluorescence corresponded with those of riboflavin determined at the same time. Duggan *et al.*[8] give 520 mμ as the fluorescence maximum of riboflavin; it is probable that the

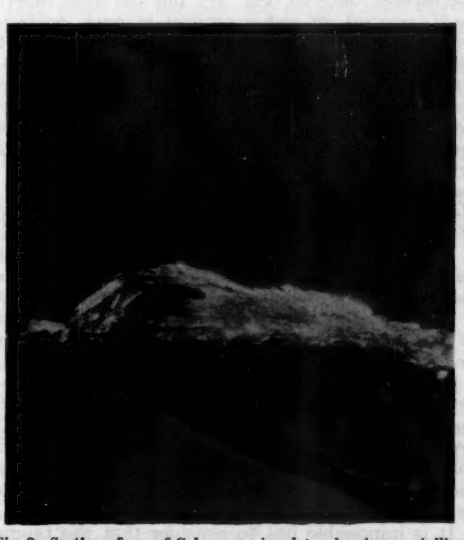

Fig. 2. Section of eye of *Galago crassicaudatus* showing crystalline tapetum lying between the retina and the choroid (polarized light)

Fig. 3. Crystals deposited from solution of tapetal material in 1 per cent formic acid

maximum at 530–550 mμ found in experiments is due to slight instrumental error. The tapetal material corresponded exactly with free riboflavin in solubility, chromatographic behaviour, formation of a chloroform-soluble substance on irradiation with ultra-violet light in alkali and of a blue fluorescent substance on irradiation in acid, and in being reversibly reduced to a colourless, non-fluorescent substance by sodium hydrosulphite.

It seemed, therefore, probable that the crystalline tapetum lucidum of this lemur is made of riboflavin. The only divergence is of crystal form. Typical riboflavin crystals are needles and such needles were deposited from a 1 per cent formic acid solution of the tapetal material (Fig. 3); but the fresh tapetum itself, scraped off and examined at once, contained only plates. As the tapetum of carnivores and the choroids of some fish[9] contain very large amounts of zinc, the formic acid extract of the tapetum was examined spectrographically to see if any metal was present in abnormally large amount, but none was found. However, it seemed possible that the plate crystals of the tapetum contained riboflavin in association with some other substance. Mrs. D. M. Hodgkin very kindly took X-ray powder photographs of the tapetal material, fresh from the eye, and finds it to be identical with one of the plate forms of riboflavin obtained by recrystallizing a commercial preparation. Sakate[10] has noted plate forms of riboflavin.

Crystals of riboflavin have been described in cells of the fungus of *Erymothecium ashbyii*[11], and Euler and Adler[12] noted that the eyes of many fish contain a high concentration of riboflavin but did not report crystals. Apart from the fungus, the tapetum of this lemur seems to be the only biological material where crystalline riboflavin has been found. Riboflavin is soluble in water to 19 mgm./100 ml. at 40° C. and the biochemical reactions which deposit and maintain it as crystals in the tapetum are unknown.

It is impossible not to consider that the tapetum will influence light reception and vision. First, light passing through the retina will be reflected by the tapetum so that the reflected light will be yellow. Second, the fluorescence maximum of riboflavin is 520 mμ at neutrality[8], and this fluorescence is maximally activated by light of 445, 370 and 266 mμ. Light of 445 and 370 mμ will penetrate the eye, be absorbed by the tapetum and re-emitted as light of 520 mμ, owing to the fluorescence of riboflavin. Dodt and Walther[13] find that the sensitivity of the light-adapted retina of the cat is much greater in the tapetal than in the non-tapetal area though there is no difference in the dark-adapted eye. Dodt[14] has also found that injection of fluorescein in the albino rabbit increases the sensitivity of the retina. If lemur eyes contain visual purple with an absorption maximum of 500 mμ and hence a visual sensitivity which is greatest to light of this wave-length, it should benefit an animal to have shorter wave light transformed into light of 520 mμ. The absorption by visual purple is 50 per cent maximal at 445 mμ and 90 per cent maximal at 520 mμ[15]. In both these ways —as a reflector, and as a fluorescing substance—riboflavin may therefore increase the stimulus received by the light-sensitive cells.

I wish to thank Dr. H. Davson for the gift of two lemurs (*Galago crassicaudatus*), Prof. R. T. Williams and Mr. Rosen for determining the fluorescence spectrum of the tapetal extract, Dr. H. H. le Riche for examining the tapetum spectrographically and Mr. Reading for help with ultra-violet microphotography.

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Gas Secretion in Coregonids

It is known that the coregonids do not possess a counter-current system in the vascularization of the swim-bladder. In his classical work Hüfner[1] showed that *C. acronius* has a gas content in the swim-bladder consisting mainly of nitrogen—some 99 per cent. This was later verified by others[2–4] on *C. acronius* and related species.

Then the question arose whether this gas mixture is primarily secreted. All attempts by artificial stress to make coregonids secrete have hitherto been unsuccessful.

As reported previously[4] the Norwegian *C. lavaretus* was found to secrete oxygen. A single specimen of *C. acronius* caught by me in the Bodensee in May 1957 had an oxygen content of 30·8 per cent. Assuming that periods of secretion and non-secretion occur, the question is whether the former investiga-

tions had been performed in the period of non-secretion. A further investigation on *C. acronius*, the classical material of Hüfner, was therefore initiated in October. The fishes were caught at a possible secreting period. Ten specimens were caught near Unteruhldingen by gill nets at depths of 80–100 m. Flotation measurements of the fishes gave buoyancy depths of 81–120 m. All the specimens had an oxygen content ranging from 15·2 to 18·3 per cent. By mass-spectrometry the argon/nitrogen ratio was measured, giving values of 90·1–97·0 per cent of the air.

The relatively low oxygen content may indicate that the secreting period is terminated and the oxygen is being absorbed. The low argon content is in favour of this theory[4].

The same process has been shown by experiments by me to occur in a physoclist fish (*Gadus callarias*). The fish was over-inflated with a mixture of 23·4 per cent nitrogen and 73·7 per cent oxygen. After 4 days the fish showed normal buoyancy with a gas content in the swim-bladder consisting of 95·5 per cent nitrogen and 3·7 per cent oxygen.

The results obtained indicate that the problem of secretion is common for the physostome and physoclist fishes, and the lack of a counter-current system does not exclude oxygen secretion.

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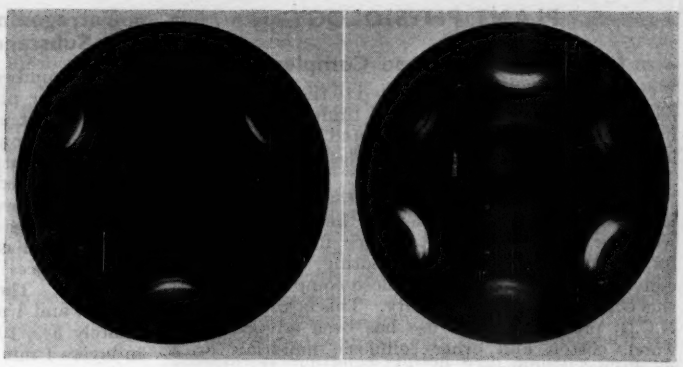
A Critical Test of Antigenic Relationships

A need has long existed for a simple, direct method for determining whether cross-reacting antigens are identical, or merely similar. Isolation and immunochemical characterization of individual antigens are often impossible. Measurement of precipitation or agglutinin titres, or of optimum proportions, are generally too crude to make distinction between identity and similarity possible, and may lead to confusing results[1]. Wodehouse[2] has reported the method of cross-neutralization to be unsuited for antigenic analysis of allergens.

Introduction of the immuno double-diffusion gel plate technique by Ouchterlony[3] apparently provided the required means for studying antigenic relationships. Complete fusing of precipitation bands of two antigens was taken to indicate antigen identity. Spur information was postulated, required and, in many cases, observed in antigen similarity without identity. Unfortunately, the conventional Ouchterlony technique can be deceptive. Its application has misled several investigators to postulate an identity of the major antigen(s) of the pollens of different species of grasses[4–6].

Re-investigation of grass pollen antigen relationships by a new agar gel technique has produced conclusive evidence of antigenic similarity rather than identity. The method is based on a modification of a pattern and technique published previously[7,8]. It is simple and permits analysis of complex antigen mixtures as well as isolated antigens.



(*a*) (*b*)

Fig. 1. Difference between precipitation band intensities of homospecific and cross-reacting heterospecific antigen/antibody systems. Outer wells contain, alternately, extracts of brome (*Bromus mollis*) and cocksfoot (*Dactylis glomerata*) pollens, starting with brome in top well. *a*, Antiserum to cocksfoot pollen in central well; *b*, antiserum to brome pollen in central well

Patterns are cut in the agar with an accurately tooled cutting instrument (obtainable from the Shandon Scientific Co., London, S.W.7). Two plates are used for the comparison of two antigen solutions. In the central well of one plate is placed 0·2 ml. antiserum to one of the antigen solutions. The other plate similarly receives the antiserum to the other solution. Antibody gradient is established in the agar by incubating the plates with the sera at 37° C. for 24–72 hr. Suitable concentrations of the two antigens are then placed in alternate circumferential wells in both plates and the plates incubated for a further 24 hr.

If the antigens are identical, the precipitation patterns at all wells are of equal intensity. Where a similarity without identity exists, alternate wells will show strong and weak precipitation band patterns, the positions being reversed in the two plates. In each plate the homospecific antigen gives strong bands, the related heterospecific antigen weak bands (Fig. 1).

The technique has been thoroughly tested on both complex and simple antigen systems. It has been found to be a critical and discriminating test of antigenic relationships. Extension of observations and theoretical considerations will be made the subject of a subsequent paper.

Photographs of the gel plates were made on the Lawson apparatus[9].

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PLANT PHYSIOLOGY

Copper–Cellulose Complexes

Our attention has been directed to the fact that our recent paper[1] on the subject of timber preservation by copper compounds is being quoted in the literature[2] in support of the copper–cellulose hypothesis of Abrams and Bottoms[3].

These workers and their associates have concluded, largely from indirect evidence, that after treating wood or cellulose with a copper formate solution followed by autoclaving or heating, the copper is converted into a copper–cellulose complex and that this complex confers durability. This is known as the N.C.G. process, and its use has been advocated for wood, cotton and other cellulosic materials as a preservative measure.

During our examinations in the electron microscope[1,4] of wood treated with water-soluble preservatives or aqueous solutions of metal salts, characteristic electron diffraction patterns were noted which were interpreted as referring to metal–cellulose complexes in the wood. This interpretation was later confirmed[5,6], and the electron-diffraction diagrams were shown to arise from a two-dimensional array of metal atoms adsorbed on to the surface of cellulose microfibrils.

The properties of this metal–cellulose complex, however, do not appear to be consistent with the claims of Abrams and Bottoms. We have found that complexing takes place in the cold from aqueous solutions of copper salts so that no heat is necessary for the adsorption and, in addition, the electron diffraction pattern given by the complex remains unchanged after heat treatment. Cations from solutions of metal salts, other than those of copper, form a metal–cellulose complex so that the reaction is not restricted to copper formate solutions.

Abrams and Bottoms have claimed that N.C.G.-treated cellulose is resistant to hydrolysis and will not dissolve in concentrated hydrochloric acid, whereas we have found that, in the case of the complex detected by means of electron diffraction analysis, the 'bound' copper is instantly removed by dilute acids.

Thus, while our investigations have confirmed the existence of a metal–cellulose complex, the configuration of which has been elucidated by means of electron diffraction analysis, the general behaviour of this complex does not resemble that of the copper–cellulose complex postulated by Abrams and Bottoms, and our findings can in no way be taken to support their copper–cellulose hypothesis.

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Tetragonin : a Yeast Growth-regulating Substance from *Tetragonia expansa*

The number of antimicrobial substances isolated from higher plants is small. Recently, studies with *Tetragonia expansa* or New Zealand spinach have shown it to contain a water-soluble component which we have tentatively named 'tetragonin'. Tetragonin is characterized by a narrow spectrum, being active apparently specifically upon *Saccharomyces* spp.

Activity tests were conducted with the agar diffusion paper disk method[1] using 1-day-old cultures of *Saccharomyces carlsbergensis* ATEE 9080 as test organism. The medium containing 2 per cent malt extract and 1 per cent agar, inoculated with approximately 5×10^7 cells/ml., was spread on glass plates in layers 1 mm. thick.

A preparation was purified by addition of chloroform to the centrifuged juice obtained from the stems of well-developed plants. The supernate was kept on a steam-bath for 10 min. and then centrifuged. The addition of one part ethanol to two parts of the supernate resulted again in precipitation. This supernate was dried at 50° C. and dissolved in methanol. After drying, a hygroscopic, yellow, sweet-smelling substance was obtained.

A methanolic solution of this partially purified substance was chromatographed on Whatman No. 1 filter paper. The dried chromatograms were placed on top of agar plates inoculated with *Saccharomyces carlsbergensis*. The R_F values thus obtained with 3 : 2 mixtures of methanol–water were 0·44–0·46, with 3 : 2 mixtures of ethanol–water 0·39–0·40 and of 3 : 2 mixtures of acetone–water 0·38–0·39. The same R_F values were obtained using the eluate of the chromatogram and also with the crude leaf juice. Tetragonin is very soluble in water, soluble in methanol, scarcely soluble in absolute ethanol and *iso*propanol, and insoluble in benzene, carbon tetrachloride, toluol and chloroform. The compound is stable at 100° C. for about 20 min., then undergoing decomposition. This decomposition with respect to time is logarithmic. The relationship between zone diameter and the logarithm of concentration is a straight line. Tetragonin dried on filter paper retains its activity for at least one year.

Tetragonin in high concentration inhibited, but in lower concentration stimulated, the multiplication also of several types of *Saccharomyces cerevisiae* and of *S. cerevisiae* var. *ellipsoideus*, in addition to *S. carlsbergensis*. No activity was observed with the following micro-organisms :

Yeasts : *Schizosaccharomyces octosporus*, *Endomyces magnusii*, *Sporobolomyces* sp., *Endomycopsis fibuliger*, *Rhodotorula gracilis*, *Torulopsis utilis*.
Bacteria : *Escherichia coli*, *Serratia marcescens*, *Bacillus subtilis*, *B. cereus*.
Actinomycetes : *Actinomyces roseus*, *Streptomyces floridae*, *Proactinomyces roseus*, *Nocardia grisea globispora*.
Phycomycetes : *Rhizopus nigricans*, *Mucor* sp.
Ascomycetes : *Aspergillus ruber*, *Penicillium striatum*.
Basidiomycetes : *Puccinia graminis*
Fungi Imperfecti : *Aspergillus niger*, *A. flavipes*, *Penicillium chrysogenum*, *P. notatum*, *Trichothecium roseum*, *Colletotrichum lini*, *Botrytis cinerea*, *Cercospora beticola*, *Pullularia pullulans*.

Tetragonin is present throughout the plants, and though its concentration varies considerably during the period of cultivation, it is always the highest in the roots. In the young plants the leaf juice shows higher activity than that of the stem, but as the plant ages, the activity of the stem becomes higher than the activity of the leaves, while the activity of the lower stem parts approaches that of the roots. Green unripe fruit show an activity between that of the leaves and

stems. The aqueous extract of the dry ripe fruit showed no signs of activity.

These observations indicate a new antibiotic substance from a higher plant. That the antibiotic is very specific for *Saccharomyces* spp. may lead to industrial application. That the concentration in the plant roots is the highest may indicate an ecological role, a feature also indicated by the macrocounteractions observed in Nature.

These experiments were begun in the Plant Breeding Research Institute, Sopronhorpacs, Hungary, and were finished at the Universities of Wisconsin and Bologna.

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Separation of Anthocyanins from Plant Extracts

ALTHOUGH cellulose column chromatography[1] is generally useful for the separation of anthocyanin mixtures, difficulties may be encountered in applying this technique in the presence of large amounts of other flavonoid materials. Thus, in the case of complex petal extracts, overlapping of bands can occur so that the anthocyanins are contaminated with other pigments; and in the case of extracts containing mobile leuco-anthocyanins, the anthocyanin bands are located within a broad diffuse zone containing the former compounds. While these difficulties can be overcome by further purification involving partition between solvent systems, or repeated cellulose column chromatography, a very convenient and effective method is provided by preliminary treatment on a column of polyamide[2–4].

The general application of polyamide (powdered nylon) columns in the purification of flavonoids has already been reported[3,4], the separations achieved depending on two factors: the greater solubility of glycosides in water as compared with aglycones, and the strong absorptive capacity of the powdered nylon for hydrogen-bonding phenolic groups. Thus flavonoid glycosides can be separated from their aglycones by using aqueous methanol followed by anhydrous methanol for elution; but compounds of the same class cannot be separated from one another by this method. It seemed likely that using a combination of the two absorbents (cellulose favouring the retention of water-soluble compounds, polyamide the reverse) it would be possible to separate most mixtures of flavonoid compounds.

Preliminary investigations showed that anthocyanins and anthocyanidins are only slightly retained by polyamide columns, being readily eluted by the usual anthocyanin solvents providing they are sufficiently acid to prevent fading of the pigment. The upper layer of butanol – 2 *N* hydrochloric acid was found to be most suitable, and had the added advantage that the eluates could be applied directly to the cellulose column[1]. Addition of two parts by weight of 'Celite' to the polyamide hastened the movement of the solvent through the column and did not greatly diminish the absorptive properties of the polyamide.

The polyamide–'Celite' mixture was packed as a slurry in the solvent system and pressed firmly into the column to a uniform compactness using a closely fitting tamper. The pigment extracts were added as a strong solution in the solvent system, to which a little methanol was added if necessary to assist the solution of the difficultly soluble components. On development with aqueous acidic butanol both anthocyanidins and anthocyanins moved rapidly down the column as one band; most of the other flavonoids were more firmly held in this solvent system but could be separated if required by further elution with aqueous or absolute methanol[3,4]. Monomeric leuco-anthocyanins, however, were found to move off the column on continued elution with aqueous butanol, and this technique offers a method for the separation of anthocyanins from leuco-anthocyanins, superior to that previously published[5], in that both fractions are recoverable.

This technique has been applied successfully to extracts of *Dahlia* petals, *Streptocarpus* petals and cacao beans, anthocyanins being obtained free from other flavonoid compounds. Anthocyanidins from acid-treated leuco-anthocyanin solutions could also be obtained in a pure state using this method, accompanying polymeric material being absorbed firmly on the column[3].

Such polymeric material could not be completely removed from the column even by alkali washing, but in all other cases the polyamide, which is apparently not affected by the recommended solvent system, can be freed from absorbed compounds by washing with suitable solvents, and used again. It is to be hoped, however, that this extremely useful and potentially cheap absorbent will become so readily available that this will not be necessary.

We wish to thank Dr. D. E. Hathway, British Leather Manufacturers' Research Association, for a liberal supply of polyamide, and Dr. J. Harborne, John Innes Horticultural Institution, for a gift of pure anthocyanins.

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Effect of Coumarin on the Germination and Growth of Rice Seedlings

UNSATURATED lactones like coumarin, parasorbic acid, etc., came to prominence after the postulation of blastocholine, the group of unknown substances from the ripe fruits which were found to inhibit the germination of corn seeds. Work was further

extended to study the physiological behaviour[1] as well as cytological effects[2] produced by these unsaturated lactones. Coumarin at high concentrations has been reported to have inhibitory effects in several plants[3–7]. The present investigation was designed to study the effect of coumarin (the lactone of *o*-hydroxy-*cis*-cinnamic acid) at various concentrations on the germination and growth of rice seedlings.

Graded seeds of the early variety of rice, *N.* 136, were soaked separately in the different concentrations, 0·5, 1, 5, 10, 100 and 1,000 parts per million of coumarin. Another set soaked in distilled water served as the controls. After 72 hr. soaking the seeds were thoroughly washed with distilled water and allowed to grow on moist filter paper in Petri dishes in the dark at room temperature. Three replications were maintained for each concentration. Six seedlings were taken at a time at random from each Petri dish, and readings were recorded at intervals on the length of the longest root, length of shoot, total fresh weight of all the roots and total fresh weight of the shoot.

The inhibitory effect of coumarin on the germination and growth of rice seedlings at high concentrations was very conspicuous. Seeds treated with 1,000 parts per million did not sprout at all, whereas the percentage of sprouting was almost the same as the controls in all other concentrations. Though the seeds treated with 100 parts per million sprouted as usual, their subsequent growth was very much adversely affected by this concentration. The radicle in this case emerged much later than the plumule and was marked with a conspicuous swelling of the hypocotyl. The initial inhibitory effect of this concentration, however, did not persist for long and rapidly diminished with the increase in the age of the seedlings. Lower concentrations behaved in a very different way. Much lower concentrations such as 0·5 and 1 parts per million produced significant accelerating effect on the growth of root as well as shoot. The maximum effect of 14·46 and 14·45 per cent increase in the length of the longest root and the shoot together with 63·27 and 29·12 per cent increase in fresh weights of all the roots and the shoot respectively over the controls was observed in the lowest concentration of 0·5 part per million.

With the increase in concentration to 5 parts per million a bifurcation in the effect of coumarin was observed in that the growth of the roots was inhibited while the growth of the shoot was still maintained on the accelerated side. With still further rise in concentration to 10 parts per million the inhibition of the growth of the roots was intensified and the direction of growth of shoot was reversed from that of promotion to inhibition. This onset of inhibitory effect simultaneously on both the roots and shoot which started at 10 parts per million persisted all through in the higher concentrations. The maximum effect of 56·56 and 36·31 per cent decrease in length of the longest root and the shoot together with 63·27 and 23·55 per cent decrease in fresh weights of all the roots and the shoot respectively in comparison with the controls was noted with 100 parts per million. Thus two things were marked from the behaviour of coumarin: (*a*) the ranges of concentration for acceleration of root and shoot growth are different, the optimum range of concentration for elongation of shoot being higher than that for root; (*b*) the accelerating effect was maximum at very low concentrations, with a gradual diminution of this effect with the rise in concentration and ultimately culminating in a reverse effect of inhibition beyond a certain stage at higher concentrations. Thus as has been observed for indoleacetic acid[8], roots and stems react in a comparable way to coumarin, their growth being inhibited by relatively high and promoted by relatively low concentrations.

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BIOCHEMISTRY

Reduction of Menadione in Hexane by Chlorophyll *a* under Ultra-violet Irradiation

We have found that chlorophyll can reduce vitamin K upon illumination. This reaction can be followed by the loss of fluorescence induced by exposure of chlorophyll to light in the presence of vitamin K. This loss of fluorescence occurs at concentrations and intensities of illumination at which the fluorescence of chlorophyll alone does not vanish. The reduction of vitamin K to the hydroquinone form can be shown by reduction of 2,6-dichlorophenol-indophenol.

The following experiments illustrate this finding. 1·85 mμmoles of chlorophyll *a* were mixed with 5 μmoles of menadione (2-methylnaphthoquinone, vitamin K_3) in 5 ml. hexane. The characteristic red fluorescence of chlorophyll *a* appeared whenever this solution was illuminated by light of wave-length 365 mμ from an ordinary black light source. Prolonged illumination by this source caused the fluorescence to fade. This was apparent within 15 sec. and extinction of the fluorescence was complete within 5 min. The fluorescence did not reappear within 48 hr. A solution of chlorophyll at the same concentration, without menadione, was not bleached under these conditions, nor did its fluorescence fade.

One method of analysis of vitamin K is to titrate its reduced (hydroquinone) form with 2,6-dichlorophenol-indophenol[1]. This reduction decolorizes the blue dye. 1 ml. of an aqueous solution of the sodium salt of 2,6-dichlorophenol-indophenol (1·33 μmoles) was decolorized to about half the original intensity of its blue colour when shaken vigorously with a chlorophyll–menadione solution which had been illuminated half an hour previously. Further shaking under 365-mμ illumination decolorized the dye completely in about 5 min. Neither chlorophyll nor menadione separately was able to reduce 2,6-dichlorophenol-indophenol under these conditions, nor was the dye itself decolorized when illuminated and shaken with hexane. Menadione itself reduced the dye when illuminated ten times as long as sufficed for decolorization of the dye in the presence of both

chlorophyll and menadione. The same results were obtained with de-aerated solutions under nitrogen. The blue colour of the dye could be brought back after decolorization by oxidation with a very dilute aqueous solution of iodine and potassium iodide.

A number of reactions have been demonstrated by these experiments. Excitation of chlorophyll[2,3]:

$$\text{Chl} + 2\,h\nu \rightarrow \text{Chl}^* \qquad (1)$$

Transfer of electrons to menadione (K_3):

$$2\,\text{Chl}^* + K_3 + 2\,H^+ \rightarrow 2\,\text{Chl}^+ + H_2K_3 \qquad (2)$$

Transfer of electrons to 2,6-dichlorophenol-indophenol (DCIP):

$$H_2K_3 + \text{DCIP} \rightarrow H_2\text{DCIP} + K_3 \qquad (3)$$

The concentrations used in our experiment were such that the chlorophyll had to turn over at least a thousand times for complete reduction of the dye to occur. Therefore, a follow-up reaction to (2) must occur in order to return Chl+ to its original form. Since this reaction occurs when an aqueous phase is added to the system, we believe that the follow-up reaction consists of the oxidation of water:

$$H_2O + 2\,\text{Chl}^+ \rightarrow 2\,\text{Chl} + 2\,H^+ + \tfrac{1}{2}\,O_2 \qquad (4)$$

The occurrence of reaction (4) still has to be established, however.

The reduction potentials[4] involved in these reactions are:

$$2\,H^+(10^{-7}M) + K_3 + 2e \rightarrow H_2K_3 \qquad E^0 = 0{\cdot}009\ \text{V}. \quad (5)$$

$$2\,H^+(10^{-7}M) + \text{DCIP} + 2e \rightarrow H_2\text{DCIP} \qquad E^0 = 0{\cdot}217\ \text{V}. \quad (6)$$

$$2\,H^+(10^{-7}M) + \tfrac{1}{2}\,O_2 + 2e \rightarrow H_2O \qquad E^0 = 0{\cdot}815\ \text{V}. \quad (7)$$

The potential of half-reaction (5) shows that the reduction of menadione uses radiant energy absorbed in reaction (1) as activation energy, but that no energy storage in a thermodynamic sense has taken place. Other vitamin K components or analogues have more negative reduction potentials, so that energy storage would occur even in a thermodynamic sense upon the reduction of these compounds. The reversal of half-reaction (7), which is involved in reaction (4), would indicate a considerable storage of energy in the course of the latter reaction.

We hope that the reactions reported here will prove helpful in studying the mechanism of photosynthesis as well as in converting the energy absorbed by chlorophyll into useful products. Work leading to further elucidation of these reactions is being continued.

This work was supported by the Physical Sciences Division Research Committee of Stanford Research Institute.

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Determination of Molecular Weights of Polysaccharides by Over-oxidation with Periodate

IN addition to its capacity to oxidize α-glycol groups, periodate oxidizes C—H groups flanked by two α-carbonyl groups[1]. Such structures are exposed in the reducing-end units of 1 : 2-, 1 : 3- or 1 : 4-linked aldohexopyranose oligosaccharides when the α-glycol groups have been oxidized.

The requisite carbonyl groups for activation of the C—H bond are found as aldehyde groups. The oxidation of the C—H group creates new α-glycol centres and further oxidation (over-oxidation) ensues. The oligosaccharide is therefore slowly eroded from its reducing-end unit with the evolution of carbon dioxide from the carbon atom carrying the activated hydrogen. The reaction continues either until the molecule is completely converted into carbon dioxide, formic acid and formaldehyde, or until structures are encountered which are no longer over-oxidizable, for example 6-substituted monosaccharide units. This behaviour has previously been used for locating the position of 6-substitution in an oligosaccharide[2]. Another use of the over-oxidation reaction is in determination of degree of polymerization of an oligosaccharide, since the rate of over-oxidation is dependent on the content of reducing-end groups. When the laminaridextrins (1 : 3-linked β-glucose oligosaccharides)[3] were over-oxidized in unbuffered sodium metaperiodate at room temperature the rate of periodate uptake was found to be directly proportional to the reducing-end group content, and degree of polymerization of laminarin was determined by measuring its rate of over-oxidation in comparison with that of the laminaridextrins of known degrees of polymerization[4]. We have re-investigated this method in an attempt to reduce the period of measurement (> 100 hr.) and the amount of material required. The latter object was achieved by measuring the rate of liberation of formaldehyde with the sensitive chromotropic acid reagent[5]. The maltodextrins[6] (1 : 4-linked α-glucose oligosaccharides) were used as test substances.

In phosphate or bicarbonate buffer at neutral *p*H there was a marked increase in the rate of over-oxidation over that occurring in unbuffered periodate (*p*H 4); but the method was unsuitable because, in addition to the endwise erosion, a random breakdown of the polymers occurred. For example, Schardinger α-dextrin (*cyclo*hepta-amylose), which is non-reducing and should not yield any formaldehyde, produced 1·61 mol. prop. of aldehyde during 22½ hr. oxidation in phosphate buffer *p*H 7·0 at 23° C. Recourse was had to the use of acid media and in acetate-periodate *p*H 1·90 at 50° equimolar amounts of maltodextrins in the series maltose-maltopentaose were over-oxidized at exactly equal rates. The time of oxidation necessary for the accurate determination of the rate constant was only 2 hr. Synthetic amyloses of known average degree of polymerization[7] were then prepared and their rates of over-oxidation compared with those of the maltodextrins. The values of degree of polymerization of such amyloses determined by measurement of the rate of over-oxidation agree well with the known values of degree of polymerization of the amyloses (Table 1).

The amount of polysaccharide required for the estimation of degree of polymerization is about 1·5 mgm. and the period of measurement need not be more than 20 hr. With more material the period is

Table 1. Determination of Degree of Polymerization of Synthetic Amyloses

By synthesis*	By over-oxidation
20·1	21·5
36·4	36·6
43·7	42·3
53·7	52·4
68·7	70·1

* The amylose is synthesized by potato phosphorylase from glucose 1-phosphate and a known amount of pure maltodextrin primer. Measurement of inorganic phosphate liberated when the synthesis is terminated enables the increase in length of the primer to be calculated (ref. 7). In these experiments the primer was maltopentaose or maltopentaitol.

correspondingly less. The method probably cannot be applied to polysaccharides of degrees of polymerization of more than 100 since some depolymerization occurs in the acid medium used for the oxidation and the consequent error will increase as the degree of polymerization increases. At degrees of polymerization less than 100 the error proved to be negligible.

The method has been used in the determination of degrees of polymerization of other polysaccharides and oligosaccharides, and it is hoped to publish full details elsewhere.

We thank the Nuffield Foundation for a grant through Prof. W. T. J. Morgan to one of us (F. W. P.).

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Aerobic Fermentation of Whey by a Nitrogen-fixing Strain of *Aerobacter aerogenes*

During the course of investigations on the utilization of cheese whey by micro-organisms, a strain of *Aerobacter aerogenes* was found capable of growing in whey and increasing the total protein of the whey without requiring the addition of a fixed form of nitrogen. Various attempts to convert cheese whey into useful substances by microbiological means have been covered in the review by Wix and Woodbine[1]. Cheese whey is a waste product with a high potential energy source in the form of lactose which has been studied in this laboratory as a substrate for members of the genus *Azotobacter*[2]. This was concerned with increasing the protein content of whey by the production of bacterial cell material. *Azotobacter* will not use lactose. Since we found that hydrolysis of the lactose must be followed by the removal of salts and other toxic ingredients in order to support growth of *Azotobacter*, attention was directed to other micro-organisms. An economic advantage of the genus *Azotobacter* is its nitrogen-fixing ability. Hence, interest was turned to a nitrogen-fixing strain of *Aerobacter aerogenes* which was recently discovered in this laboratory[3]. Pirt[4] has shown that the efficiency of conversion of substrate carbon to cell carbon and carbon dioxide by *Aerobacter* is directly proportional to the degree of oxygenation of the culture. This indicated that fermentation of whey could be accomplished under aerobic conditions.

All fermentations reported here were carried out in New Brunswick Model *F*07 fermentors of 7·5 l. capacity. 5 l. of acid whey were neutralized with potassium hydroxide, added to a fermentor, and sterilized by autoclaving at 15 lb. pressure for 15 min. The fermentors were inoculated with young cultures of *Aerobacter aerogenes* 88, stirred at 320 r.p.m., and aerated at a rate of 10 l. of air per minute. The temperature of the fermentations averaged 30° C. Excessive foaming was controlled by the addition of 'Dowex *AF* Antifoam'. The fermentations were sampled periodically over their 6–12 day incubation periods. The suspended solids, including the cells, were removed by centrifugation, recovered by acetone trituration, and dried to constant weight. Microkjeldahl determinations were made for total nitrogen and were the basis of the protein values presented.

Analysis of a typical fermentation showed the protein of the liquid whey culture to be 10·9 gm./l. before fermentation and 15·7 gm./l. after 10 days, an increase of 4·8 gm./l., or 44 per cent. Interest was confined, however, to the centrifugable portions of the culture. The dry weight of this portion increased from 10 gm./l. at the outset to 13·7 gm./l. at the termination of 10 days incubation, an increase of 3·7 gm./l., or 37 per cent. The protein of the centrifugate was increased from 42·9 to 68·1 per cent during fermentation, an increase of 59 per cent. As indicated in Fig. 1, total nitrogen increased throughout the fermentation periods. These findings appear to indicate that some nitrogen fixation has occurred with aerobic cultural conditions. In this connexion, the report by Pengra and Wilson[5] shows a several-fold increase in cell nitrogen by growing *A. aerogenes* anaerobically, and adds that under their conditions

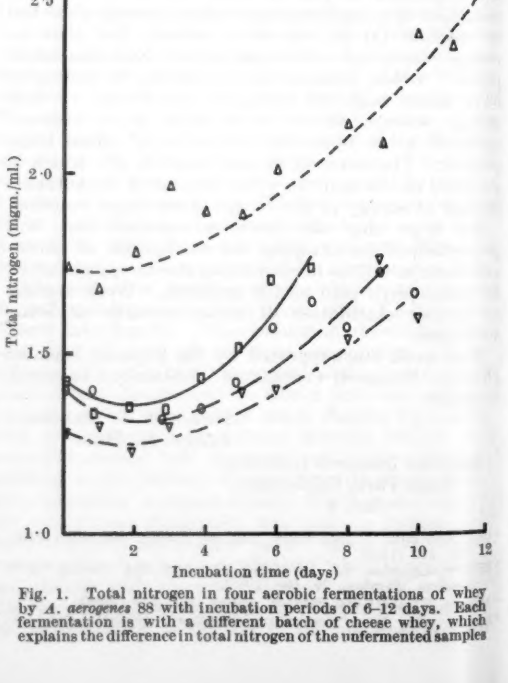

Fig. 1. Total nitrogen in four aerobic fermentations of whey by *A. aerogenes* 88 with incubation periods of 6–12 days. Each fermentation is with a different batch of cheese whey, which explains the difference in total nitrogen of the unfermented samples

their strains did not fix nitrogen aerobically. This is, of course, unlike the strain employed by Jensen[6], which fixed nitrogen equally well aerobically or anaerobically. One might also mention that Pirt[4] shows that in the presence of fixed nitrogen maximum conversion of carbohydrate to cell material occurs aerobically. Whereas Pengra and Wilson[5] employed a mineral salts and sucrose medium, Jensen[6] found a small amount of yeast extract or agar necessary. We were also unable to show nitrogen fixation unless whey or agar was present. This appears to suggest that a growth factor is required for aerobic nitrogen fixation by some strains of the genus *Aerobacter*.

This investigation was supported in part by a grant from the National Science Foundation.

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Amino-Acid Metabolism in Wool Roots

Follicle material referred to as wool roots can be prepared in quantity from fresh sheep-skin by Ellis's method[1]. Each wool root consists of a bulb region, a pre-keratinization region and some fully keratinized fibre. Frequently, the inner root sheath is found to be attached to the wool root. Previous studies of homogenates of wool roots revealed the presence of several enzymes[2,3], some of which have been localized in hair follicles by histochemical methods[4,5]. Very little investigation of enzymes concerned with protein metabolism in the hair follicle has been made, despite the fact that protein synthesis is the major activity of this tissue.

The demonstration of free α-amino- and α-oxo-acids in wool roots led Ellis, Gillespie and Lindley[2] to suggest that enzymes could be present which participate in the tricarboxylic acid cycle as well as in transamination reactions. In the present work transaminase activity has been demonstrated. In addition it has been found that another enzyme commonly found in tissues actively engaged in protein synthesis is present, namely, transpeptidase[6,7].

A homogenate was prepared by macerating 5 gm. wool roots with 50 ml. water in a Waring blendor, filtering through coarse 'Terylene' cloth, centrifuging at 2,000*g* and dialysing the supernatant against 0·02 *M* phosphate buffer *p*H 7·4 overnight at +2° C. The supernatant was more satisfactory to use than the original homogenate because of the difficulty of removing the endogenous amino acids from the latter.

The systems used were :

(*a*) For transamination : 0·7 ml. reaction mixture containing 0·5 ml. extract or 0·02 *M* phosphate buffer *p*H 7·4, 5 μgm. pyridoxal phosphate, 20 μmoles α-oxo-acid and 20 μmoles L-amino-acid ; incubated for 2 hr. at 37° C.

(*b*) For transpeptidation : 0·6 ml. reaction mixture containing 0·5 ml. extract or 0·02 *M* phosphate buffer *p*H 7·4, 20 μmoles amino-acid (or water), and 2 μmoles neutralized glutathione ; incubated for 30 min. at 30° C.

(*c*) For citrulline iminase : (1) 1·0 ml. reaction mixture containing 0·5 ml. extract, 5 μgm. pyridoxal phosphate, 0·02 *M* potassium dihydrogen phosphate, 15 μmoles L-citrulline, 20 μmoles magnesium chloride, 5 μmoles neutralized adenosine triphosphate, and 2 μmoles ammonium chloride ; incubated for 30 min. at 37° C. ; (2) as (1) with 0·05 *M* borate instead of potassium dihydrogen phosphate and 15 μmoles L-arginine instead of L-citrulline and without ammonium chloride.

Following incubation, the reactions were stopped by the addition of 1 ml. warm ethanol ; in (*b*) the ethanol contained 2·2 μmoles N-ethyl maleimide. The clear supernatants were dried *in vacuo* and then applied to Whatman No. 1 paper ; samples (*a*) and (*c*) were developed in 80 per cent aqueous phenol, and (*b*) in 80 per cent aqueous *n*-propanol for 24 and 240 hr. respectively.

So far it has been possible to demonstrate the formation of alanine from pyruvic and aspartic acids, and glutamic acid from α-oxoglutaric acid and alanine or citrulline. It is of interest that citrulline, which occurs in the free state in wool roots[8] as well as combined in the inner root sheath[9], participates in transamination.

It was not possible to obtain evidence of citrulline iminase activity[10]. This enzyme catalyses the reversible conversion of citrulline to arginine and has been suggested as a possible constituent of hair follicles[11].

Evidence for the presence of γ-glutamyl transferase activity[6,7] in wool root homogenates was found by the demonstration of the formation of γ-glutamyl glycine from glutathione and glycine. It is perhaps significant that Haurowitz *et al.*[12] have recently provided evidence for the occurrence of γ-glutamyl residues in wool and the present finding of transpeptidase activity could have relevance to their formation. In addition to transpeptidation, the chromatograms indicated that wool roots probably also possess peptidase and/or protease activity, although cysteinyl-glycinase[13] activity was weak or absent. This enzyme is usually found in conjunction with transpeptidase activity.

We wish to thank Dr. F. J. R. Hird for a gift of adenosine triphosphate, glutathione and α-oxoglutaric acid, Dr. A. W. Rodwell for pyridoxal phosphate and Miss C. M. M. Mackinnon for technical assistance.

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Role of Lysine in catalysing Ester Hydrolysis

Recently, Gero and Withrow[1] have cited the catalysis of alkaline triglyceride hydrolysis by lysine as a chemical model of a biological reaction. They postulated a bifunctional[2] attack by lysine upon the carbonyl O and C of the ester linkage as the mechanism of this hydrolysis.

We believe that some objections can be made to their arguments for this mechanism. They have stated, "It stands to reason that the hydrogen bonds which the ε-ammonium group is to form with the carboxyl group of lysine and the O of the ester should be strongest when the N does not hold its hydrogens too tightly, because that is when they will be most readily donated for a hydrogen bond. Such would be the case just below the *p*H at which the ε-ammonium group of lysine loses a hydrogen and its positive charge. That happens at *p*H 9·5, so that lysine should be maximally active as a catalyst for ester hydrolysis around *p*H 8–9". The authors are clearly implying that N—H bond-strength is a function of *p*H. This, of course, is not the case. Instead, since they are describing the competition of several bases for protons, one would expect the usual arguments for acid-base equilibria to be applicable. In this case they are:

$$K_1 = \frac{[\epsilon NH_2]\ [R{-}\overset{\oplus OH}{\overset{\|}{C}}{-}OR']}{[{-}NH_3{\oplus}]\ [R{-}\overset{O}{\overset{\|}{C}}{-}OR']}$$

$$K_2 = \frac{[R{-}\overset{\oplus OH}{\overset{\|}{C}}{-}OR']}{[H{\oplus}]\ [R{-}\overset{O}{\overset{\|}{C}}{-}OR']}$$

$$K_3 = \frac{[\epsilon NH_2]\ [H{\oplus}]}{[\epsilon NH_3{\oplus}]}$$

Since K_3 has a value of $10^{-10.53}$ for lysine[3] and K_2 should be about $10^{6.0}$, depending upon the nature of the substituents of the carbonyl group[4], the concentration of the reacting species, $-NH_3{+}$ and $R{-}\overset{O}{\overset{\|}{C}}{-}OR'$, in the first equilibrium should be maximal and independent of *p*H over at least the *p*H range 4·0–9·5. Below the former *p*H the rate of ordinary acid hydrolysis and the protonation of the lysine carboxyl group would have to be taken into consideration. Consequently, the rate of the hydrolysis catalysed by lysine should be maximal and constant over this *p*H range. Inspection of their results does not show this to be the case. Instead the decrease of the hydrolysis rate with decreasing alkalinity below *p*H 8·6 is seen to follow closely the expected protonation of the α-amino group.

A further objection can be made to their choice of *p*H 8–9 as the range of maximal catalysis. The ε-ammonium group would not be expected to be appreciably dissociated below *p*H 9·5 since its pK_A is 10·53. Catalysis then should not fall off below *p*H 9·0. Again, their results do not show this to be true.

Therefore it seems more likely to us that this is an example of general base catalysis similar to that

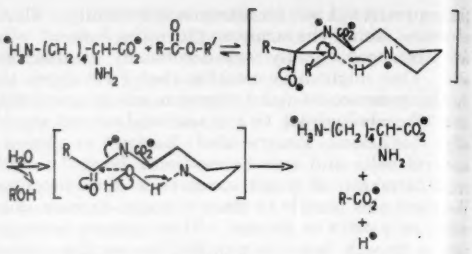

Fig. 1

reported for the imidazole group[5]. That is, the picture of bifunctional catalysis shown in Fig. 1 would be predicted.

An alternative to the second intermediate would be the co-ordination of a hydroxyl group by the ε-amino group into a position favouring its attack upon the carbonyl C. However, there is little to choose between the two possibilities.

Lysine as a ring structure as postulated by Gero and Withrow is sterically less suitable as a catalyst in this reaction sequence than it is in an open-chain form. Assumption of such a ring structure would be possible only with dissociation and loss of positive charge by the α-amino group, since it would otherwise require apposition of the two positive poles in the molecule. Consequently, the catalytic ability of lysine should decrease as the possibility for formation of ring structure increases above *p*H 8·95, the pK_A of the α-amino group[3]. This is precisely what Gero and Withrow observed.

Consideration of the reaction sequence postulated above suggests that lysine should be very reactive with aldoses (in the hemiacetal configuration) since it is in good agreement with the mechanism deduced[6] for the Maillard reaction of amino-acids with aldoses. Inspection of the literature[7–9] shows that lysine is indeed particularly reactive with aldoses over the expected *p*H range, 7·0–9·5.

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In their criticism of our paper[1], Chesbro and Hedrick make some points that are indeed well taken. Their objection to the implication that bond-strength is a function of *p*H is undoubtedly valid. However, the statement they quote from our paper does not imply such a functional relationship. Rather, we had in mind the stretching of the N—H bond which may be expected to occur before the bond breaks (more so the more alkaline the environment) and which certainly will allow the proton to function more effectively as an acidic catalyst. It is regretted

that for the sake of brevity we were not explicit enough to forestall a mistaken implication.

Chesbro and Hedrick's objections to our writing of lysine as a chelate ring and their alternative mechanism for lysine-catalysed ester hydrolysis strike us as less convincing. They state that a hydrogen bond between the carboxyl group and the ε-amino group of lysine can be formed "only with dissociation and loss of positive charge by the α-amino group, since it would otherwise require apposition of the two positive poles in the molecule". It is not apparent where the apposition of two positive poles occurs when in the chelate structure the two poles are separated by a chain of three atoms, one of them a negatively charged oxygen atom. As to their catalytic mechanism, which is an adaptation of the mechanism proposed by Bender and Turnquest[2] for ester hydrolysis catalysed by imidazole, it must be observed that in Bender's mechanism imidazole functions as a basic catalyst by virtue of the electron richness of its tertiary nitrogen :

Whether the reasoning based on the catalytic potency of the tertiary nitrogen in imidazole can be fitted without further ado to the α-amino group of an amino-acid, even with the auxiliary role which Chesbro and Hedrick assign to the ε-amino group, remains to be seen. Certainly, if their reasoning is correct, there should be at least some catalysis even by a simple amino-acid such as glycine, and this we found not to be the case. Also, if we are dealing, as Chesbro and Hedrick suggest, simply with general base catalysis similar to that reported for the imidazole group, one would expect histidine, which contains both an α-amino group and an imidazole ring, to be a more potent catalyst of ester hydrolysis than lysine. As reported in our communication, we found the reverse to be the case.

However, it is probably of minor importance which particular mechanism will eventually be accepted to interpret our findings. It is significant, in my view, that on general chemical grounds a prediction was made regarding a biological reaction and that the prediction was verified by experiment.

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Synthesis of Adenylosuccinic Acid in Preparations of Mammalian Skeletal Muscle

FROM the observation that the nitrogen-15 of labelled ammonium citrate administered to rats appears in the 6–NH_2 group of the muscle adenine nucleotides, Kalckar and Rittenberg[1] have concluded that the nucleotides take part in very rapid reversible de-amination reactions. That ammonium citrate nitrogen is similarly incorporated into rabbit skeletal muscle has been confirmed by Newton and Perry[2]. They have further demonstrated that aspartic acid is a more active donor of the 6–NH_2 group and that the enzymic activity is concentrated in the sarcoplasmic fraction of muscle.

Although the rapid reactions involved in the dephosphorylation and subsequent de-amination of adenine nucleotides to inosine nucleotides in muscle have been well established[3], little is known concerning the processes whereby the inosine nucleotides are re-aminated. The re-amination of inosine monophosphate by its condensation with aspartic acid to form adenylosuccinic acid occurs in preparations of rabbit bone marrow, whereas in muscle extracts an accumulation of adenine nucleotides has been reported to occur in the presence of inosine monophosphate with either aspartic acid[3] or creatine[4]. Although adenosine monophosphate, together with fumaric acid, is formed from the splitting of adenylosuccinic acid in water-soluble extracts of *Escherichia coli*, strain *B* [5], it is unlikely that in muscle the adenine nucleotides are resynthesized in this manner. The product of this reaction, adenosine monophosphate, has not been identified in skeletal muscle, and if formed, would be lost to the adenine nucleotide pool by its rapid and irreversible de-amination to inosine monophosphate by muscle adenosine monophosphate deaminase[6–8].

In the present work, adenylosuccinic acid was found to be formed from inosine monophosphate and aspartic acid in extracts of acetone-dried powder of the water-soluble fraction of rabbit and beef skeletal muscle. The reaction requires the presence of guanosine triphosphate, a very low concentration of which (0·01–0·02 m*M*), together with adenosine triphosphate (5 m*M*), is effective in causing the condensation, although adenosine triphosphate alone is not. During the course of the reaction adenosine triphosphate breaks down to the diphosphate apparently by rephosphorylating guanosine diphosphate—in the presence of a nucleoside diphosphate phosphokinase—to guanosine triphosphate, the splitting of which supplies the necessary free energy for the formation of adenylosuccinic acid. If adenosine triphosphate is used to rephosphorylate guanosine diphosphate formed during the reaction, 50–55 per cent of the inosine monophosphate is converted to adenylosuccinic acid. If traces of both guanosine triphosphate and adenosine triphosphate are used, in the presence of a glycolysing system for regenerating the latter from adenosine diphosphate, 90–100 per cent condensation of inosine monophosphate with aspartic acid is attained after 3-hr. incubation at 37°.

Fig. 1 shows the formation of adenylosuccinic acid in both undialysed and well-dialysed (2 days against 0·04 *M* potassium chloride) extracts of acetone-dried powder of rabbit skeletal muscle, in a reaction mixture containing 6 m*M* aspartic acid, 2·5 m*M* inosine monophosphate, 3 m*M* magnesium chloride, 4 m*M* fructose-1 : 6-diphosphate, 0·2 m*M* diphosphopyridine nucleotide, 50 m*M*, *p*H 6·9 glyoxaline buffer and 0·7 per cent protein solution. The course of the reaction was followed from the spectral change occurring as inosine monophosphate ($\lambda_{max.}$, 248 mμ) is converted to adenylosuccinic acid ($\lambda_{max.}$, 267 mμ). The triphosphates of uridine, cytidine, inosine (0·09 m*M*), and of adenosine (0·2 m*M*) could not replace the requirement for guanosine triphosphate, which increases the enzymic activity of the dialysed extracts to that of the undialysed extracts. The guanosine triphosphate is bound presumably to the enzyme causing the condensation, and is only released on exhaustive and prolonged

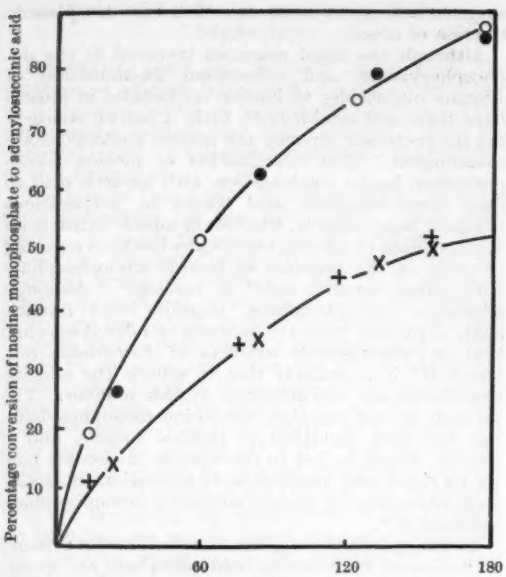

Fig. 1. The formation of adenylosuccinic acid from inosine monophosphate and aspartic acid, in undialysed extracts of rabbit muscle acetone-dried powder containing 0·005 m*M* adenosine triphosphate (●—●), in dialysed extracts containing 0·09 m*M* guanosine triphosphate and 0·005 m*M* adenosine triphosphate (○—○), in dialysed extracts containing 0·2 m*M* adenosine triphosphate (+—+) and in dialysed extracts containing 0·005 m*M* adenosine triphosphate with and without the triphosphates (0·09 m*M*) of uridine cytidine or inosine (×—×)

dialysis against 0·04 *M* potassium chloride at 0° for 8 days, by which time the enzymic activity is reduced by as much as 90 per cent. If such preparations are incubated with guanosine triphosphate and magnesium ions, and are then further dialysed for sufficient time to remove unbound guanosine triphosphate and magnesium, the activity is considerably greater than if the incubation before dialysis is carried out with guanosine triphosphate alone. The binding is apparently in the form of a complex of the enzyme, magnesium and guanosine triphosphate, in which form the enzyme is active.

The *p*H optimum of the condensation reaction is between *p*H 6·9 and 7·0. Inorganic phosphate in concentrations greater than 10 m*M* partially inhibits the reaction.

The significance of the adenine nucleotide de-aminating and re-aminating reactions in muscle is not known. If, as Kalckar and Rittenberg have suggested[1], the rates of these reactions increase with increase in muscular activity, it is possible that they play an important part in the process of muscular contraction.

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Identification of 10-Hydroxy-Δ^2-decenoic Acid in Royal Jelly

Royal jelly[1] is the sole food administered by young workers or nurse bees of the common honey bee species *Apis mellifica* to female larvæ destined to become queens. Larvæ destined to become drones (males) or workers (sexually undeveloped females) receive royal jelly during the first three days of their existence only and then a different food. The components of royal jelly responsible for its remarkable properties remain unidentified.

Townsend and Lucas[2] recognized and Abbot and French[3] confirmed that an optically inactive acid *A* ($C_{10}H_{18}O_3$) comprised the major portion of the ether-soluble fraction of royal jelly. We have identified *A* as 10-hydroxy-Δ^2-decenoic acid; royal jelly is the only known source of this compound. The acid *A* (m.p. 52° C. (found—C, 64·6; H, 9·4 per cent; equiv. wt., 187·9: calc. for $C_{10}H_{18}O_3$—C, 64·5; H, 9·7 per cent; equiv. wt. 186)) comprises approximately 70 per cent of the ether-soluble fraction and approximately 15 per cent of royal jelly. The infra-red spectrum (melt on rock salt) of *A* showed $\nu_{max.}$ at 3,480 cm.$^{-1}$ (hydroxyl), 1,710 cm.$^{-1}$ (carboxylic acid) and 1,667 cm.$^{-1}$ (unsaturation). Platinum catalysed[4] hydrogenation of *A* indicated the presence of one double bond and afforded 10-hydroxy-decanoic acid, m.p. 74° (found—C, 64·1; H, 10·9 per cent: calc. for $C_{10}H_{20}O_3$—C, 63·8; H, 10·7 per cent); Chuit and Hausser[5] quote a melting point of 75–76° for this acid. The identity of the saturated acid was confirmed by conversion to sebacic acid on permanganate oxidation and the linearity of the carbon chain in *A* thereby established.

The presence of αβ-unsaturation in *A*, indicated by strong end absorption in the ultra-violet was confirmed as follows. Oxidation of *A* with the periodate-permanganate reagent[6] which cleaves double bonds, gave suberic acid, but oxalic acid, the anticipated second reaction product, could not be detected; under the same reaction conditions, *trans*-crotonic acid gave oxalic acid. Hydroxylation[7] of *A* with osmium tetroxide gave a product *B* shown by paper chromatography[8] and ionophoresis[9] to contain a single component in addition to some starting material. Oxidation of *B* with the periodate permanganate reagent[5] gave oxalic acid as did D-tartaric acid, *meso*-tartaric acid and *erythro*-2 : 3-dihydroxybutyric acid. Reaction of *B* with periodic acid directly on Whatman No. 1 paper followed by chromatographic separation of the products gave glyoxylic acid identified as its 2 : 4-dinitrophenylhydrazone (m.p. 194–196° decomp.) after elution from the paper. When the preceding experiments were essentially complete, our attention was directed to a report by Butenandt and Rembold[10] identifying *A* as 10-hydroxy-Δ^2-decenoic acid. No chemical proof of αβ-unsaturation or olefinic configuration was presented.

The olefinic C—H out of plane bending in *trans*-compounds is characterized[11] by strong absorption near 980 cm.$^{-1}$ in the infra-red. Both *A* and 10-hydroxy-decanoic acid absorbed near this value (987 and 981 cm.$^{-1}$ respectively) probably due to C—O stretching. Sheppard and Simpson[12] have observed a strong absorption in the range 675–725 cm.$^{-1}$ for a series of *cis*-olefins; but Allan, Meakins and Whiting[11] have assigned the absorption near 820 cm.$^{-1}$ to the olefinic C—H out of plane bending in *cis*-αβ-unsaturated acids and esters. *A* and its methyl ester show moder-

ately strong absorption in the range 675–725 cm.$^{-1}$ whereas 10-hydroxy-decanoic acid does not. However, *trans*-crotonic acid and its methyl ester also absorb in this range. While the methyl ester of *A* shows no absorption near 820 cm.$^{-1}$ both *A* and 10-hydroxy-decanoic acid show weak absorption at 817 and 823 cm.$^{-1}$ respectively. Thus, on this basis, the configuration of the olefinic linkage in *A* cannot be allocated with certainty.

The biological origin of 10-hydroxy-Δ^2-decenoic acid has not been established. It is not present in the free state in nectar (collected from the hive), honey, or pollen of a representative monocotyledon (*Zea mays*), dicotyledon (*Alnus glutinosa*) and conifer (*Pinus montana*). The acid may be present in combined form or it may be a specific bee product.

10-Hydroxy-Δ^2-decenoic acid showed little activity against a representative range of bacteria and fungi; weak activity against strains of *Streptococcus pyogenes* and *Tricophyton rubrum* was displayed.

We thank Prof. M. Stacey for his interest in this work and Messrs. Glaxo, Ltd., for the biological activity assays.

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Effect of Reduced Diphosphopyridine Nucleotide on the Swelling of Isolated Mitochondria

It has been repeatedly reported that isolated mitochondria maintain a low water content if incubated in conditions favourable to oxidative phosphorylation[1–5]. Di Sabato and Fonnesu[6,7] found that this happens only when certain metabolites are used as the oxidizable substrate, for example, succinate, α-ketoglutarate and glutamate.

This communication deals with a study on the effect of reduced diphosphopyridine nucleotide on the swelling of the mitochondria in both conditions favourable and unfavourable to oxidative phosphorylation.

The preparation and incubation of mitochondria from rat liver, and the estimation of the swelling by the optical method were carried out as already described[6,7], with the difference that the readings of optical density were taken at 950 mμ. In order to establish whether reduced diphosphopyridine nucleotide is oxidized or not, soon after every reading at

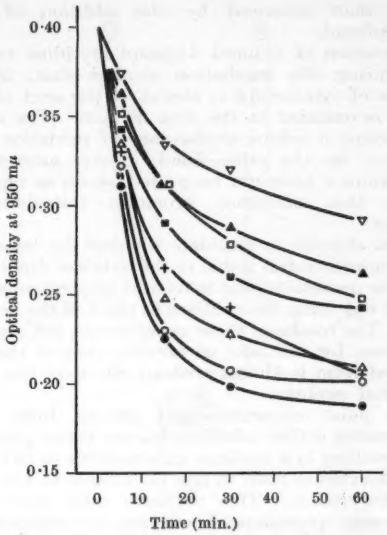

Fig. 1. Effect on mitochondrial swelling of various added substances: (1) +, control; (2) △, reduced diphosphopyridine nucleotide; (3) ○, cytochrome *c*; (4), ●, (2) + (3); (5) ▲, (2) + adenosine monophosphate; (6) ■, (5) + (3); (7) □, (3) + adenosine monophosphate; (8) ▽, (5) + 2,4-dinitrophenol

950 mμ, the optical density of the mitochondrial suspension was measured at 340 mμ.

The composition of the standard incubation medium employed was as follows: magnesium sulphate, 30 μmoles; potassium phosphate buffer, *p*H 7·2, 60 μmoles; sucrose, 690 μmoles. The additions (Fig. 1) were: adenosine-5′-monophosphate, 180 μmoles; reduced diphosphopyridine nucleotide (Sigma Chemical Co.; 90–95 per cent purity), 6 μmoles; cytochrome *c*, 0·06 μmole; 2,4-dinitrophenol, 0·6 μmole; oxidized diphosphopyridine nucleotide, 6 μmoles. The final volume, after the addition of the mitochondria, was 6 ml.

Fig. 1 shows the rate of the mitochondrial swelling in the presence of various added substances. It is apparent that reduced diphosphopyridine nucleotide alone slightly enhances the 'spontaneous' swelling of mitochondria, but, at the end of the incubation, the swelling is nearly the same as that in the control. One can also see that cytochrome *c* alone enhances the mitochondrial swelling a little more than reduced diphosphopyridine nucleotide. When the mitochondria are incubated in the presence of both these substances, the swelling is greater than in the presence of either of them separately. When the mitochondria are incubated in conditions favourable to oxidative phosphorylation, that is, in media containing reduced diphosphopyridine nucleotide and adenosine monophosphate or these substances together with cytochrome *c*, the spontaneous swelling is partially prevented. This phenomenon, however, seems to be due to the action of adenosine monophosphate, since it was also observed with cytochrome *c* + adenosine monophosphate, as well as with adenosine monophosphate alone (not shown in Fig. 1; see refs. 7 and 8). That the protection from swelling in a system containing diphosphopyridine nucleotide and adenosine monophosphate is not due to the phosphorylation-coupled oxidation of the nucleotide, is also shown by the fact that the swelling is prevented

rather than enhanced by the addition of 2,4-dinitrophenol.

Estimation of reduced diphosphopyridine nucleotide during the incubation showed that, in the absence of cytochrome *c*, almost 70 per cent of that added is oxidized in the first 30 min. The added cytochrome *c* enhances the rate of oxidation only slightly; on the other hand, greater amounts of cytochrome *c* have not been used, since, as reported above, this substance promotes mitochrondrial swelling.

In an attempt to elucidate whether the behaviour of the mitochondria is due to the oxidized diphosphopyridine nucleotide that is formed, experiments were carried out using the oxidized in place of the reduced form. The results of these experiments, not reported fully here for the sake of brevity, showed that the oxidized form is almost without effect on the mitochondrial swelling.

The most important fact arising from these experiments is that mitochondria are better protected from swelling in a medium unfavourable to oxidative phosphorylation than in one favourable to oxidative phosphorylation. This confirms once more that high-energy phosphate bonds are not essential for maintaining the mitochondria in the contracted state.

This work was aided by a grant from the Consiglio Nazionale delle Ricerche, Centro per la Patologia cellulare P. Rondoni, Milano.

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Differences in Cyst(e)ine Content between Vegetative Cells and Spores of *Bacillus cereus* and *Bacillus megaterium*

In the course of investigations on the role of sulphur amino-acids in the sporulation process of bacilli we studied the inhibitory effect of a large excess of cystine (10^{-4} *M*) on spore formation in *Bacillus megaterium*[1], and the incorporation of cystine-^{35}S and methionine-^{35}S, added in small quantities to the nutrient medium before sporulation, into sporulating cells of inhibited and of control culture[2]. The control culture, which was pre-adapted to cystine and treated with cystine just before sporulation, during sporulation incorporated considerable quantities of ^{35}S-amino-acids added at the time to the nutrient medium. During the 'cystine inhibition' the spore formation of *B. megaterium* remained for a long time in the first stage and the incorporation of labelled amino-acids was markedly lower.

Cultivating *B. megaterium* in the presence of ^{35}S-amino-acids from inoculation, we found that the free spores contained significantly more radioactive sulphur than the vegetative cells before spore formation[2]. With regard to the possibility of different cyst(e)ine contents of the vegetative cells and of spores we started to investigate these differences in both forms of bacilli.

A strain of *Bacillus cereus* (N.C.I.B. 8122) and our laboratory strain of *Bacillus megaterium* were used. Either bacillus was cultivated on a shaker at 30° C. in a liquid medium containing tryptic casein hydrolysate, 0·3 per cent; glucose, 0·1 per cent; phosphates and traces of some important ions. Cystine was added to the medium to give a concentration of 10^{-4} *M* before inoculation. The cells were harvested in order to estimate the cyst(e)ine after 12 hr. of cultivation, that is, about 2 hr. before spore formation; and after 100 hr. of cultivation, after complete liberation of spores and autolysis of the debris of sporangia. The harvested cells were killed with 10 per cent trichloracetic acid, washed, extracted with ethanol–ether (3 : 1) and heated in 5 per cent trichloracetic acid at 90° C. for 30 min. The precipitate, the fraction insoluble in hot trichloracetic acid, obtained in this way was used for the determination of cyst(e)ine content.

For the estimation of cyst(e)ine a specific method developed by Akabori[3] was used, involving reductive decomposition of proteins by hydrazine at 120° C. Hydrogen sulphide produced from both cystine and cysteine is driven out by acidification of the hydrazine with sulphuric acid and absorbed in zinc acetate solution. The zinc sulphide is estimated by the Carius method using dimethyl-*p*-phenylenediamine[4]. The nitrogen content of the precipitate was determined by the usual Kjeldahl method.

The results shown in Fig. 1 indicate that the spores of *Bacillus cereus* and *Bacillus megaterium* contain significantly more cyst(e)ine (about five times) than the vegetative cells before spore formation. This supports the hypothesis that the protein structure of spores differs substantially from that of vegetative cells. It is known that cystine, with its SS-bridges, plays an important part in the structure of some highly inert proteins, for example, keratins. A possible analogy with the structure of spores cannot be excluded. Stabilization of their protein structure

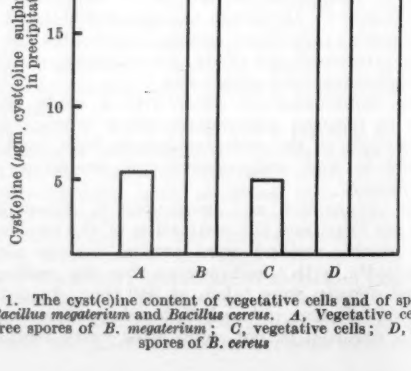

Fig. 1. The cyst(e)ine content of vegetative cells and of spores of *Bacillus megaterium* and *Bacillus cereus*. *A*, Vegetative cells; *B*, free spores of *B. megaterium*; *C*, vegetative cells; *D*, free spores of *B. cereus*

by SS-bridges may be a further mechanism contributing to the resistance of resting spores. Further details of the participation of cystine in spore formation will be described elsewhere.

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PHYSICAL SCIENCES

Thin Magnetic Films

THE preparation of thin films of magnetic alloys with specific characteristics is generally acknowledged to be a difficult task, owing to the large number of parameters involved. One such parameter, that of film thickness, might be expected to have a large effect on magnetic characteristics. The relation between this and coercivity has been studied theoretically by L. Néel[1], for film thicknesses in excess of domain wall thickness. For this condition, small variations in the thickness of the layer give rise to energy changes as domain walls are moved and lead to the relation $H_c \propto t^{-4/3}$, where H_c is the coercivity and t the average thickness. Tiller and Clark[2] have found $H_c \propto t^{-1}$ experimentally for t varying from about 250 A. to nearly 2,800 A.

To investigate this dependence more fully, an apparatus (Fig. 1) has been developed which allows the low-frequency hysteresis loop to be monitored both during deposition of the film and afterwards. The base, 1, on to which the magnetic alloy, 2, is to be evaporated is supported at the top of a flat-topped bell-jar, 3. The alloy is heated by induction from the coil, 4, and a shutter, 5, stops deposition on to the base, 1, until the alloy is evaporating freely. A Helmholtz coil, 6, produces an alternating aligning field of approximately 30 oersteds in the plane of the base, 1. Frequencies up to 1,000 c./s. have been tried, but generally 50 c./s. is used. The sensing coil, 7, consists of two rectangular windings each of 1,800 turns, with dimensions 2 in. × 1 in. The windings are connected so that the flux linkages with the evaporated specimen are additive, and are each adjusted slightly from the horizontal plane, so that the total flux linkage with the alternating aligning field is zero. Usually a small voltage is induced into the sensing coil from 50 c./s. eddy currents in metal components of the assembly and this requires separate cancellation. The output voltage from the sensing coil is thus proportional to $\dot{\varphi}$, where φ is the flux in the magnetic layer. The voltage is integrated and amplified, and a vertical deflexion proportional to φ is presented on an oscilloscope tube. The horizontal deflexion is derived by conventional means from the alternating current flowing in the Helmholtz coil. The base, 1, has generally been maintained at an elevated temperature during deposition by means of toroidally wound d.c. heaters, 8, applied to the outside of the bell jar, the magnetic field from which is negligible. The sensitivity of the apparatus as described is such that a recognizable hysteresis loop is obtained when the thickness of the layer is about 150 A., and no

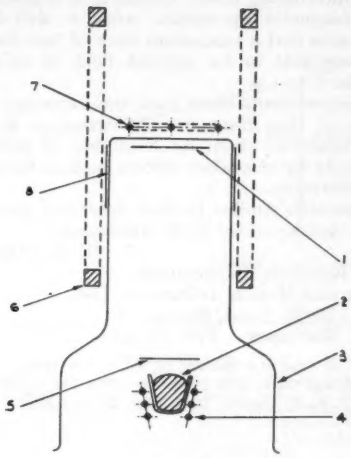

Fig. 1

attempt has been made to improve upon this figure, so far.

Nearly two hundred evaporations have been made using the apparatus, the majority using lime soda glass for the base, 1. Substratum temperatures have ranged from 250° to 400° C., and alloy compositions from 75 per cent nickel, 25 per cent iron to 85 per cent nickel, 15 per cent iron. In the great majority of evaporations the coercivity changes little as the thickness varies from 150 A. to 1,500 A. If the evaporation is then continued up to 10,000 A., either a steady decrease of coercivity from its initial value of 1–2 oersteds to about 0·5 oersted is seen, or a sudden increase to 10–20 oersteds occurs at a thickness of about 2,000 A. The rapid increase in coercivity appears to be associated with atomic arrangement within the layer, since it continues for several seconds if the vapour stream is terminated during the increase with the shutter, 5. Moreover, the coercivity of such a layer can be reduced to 1–2 oersteds by annealing at 350–400° C. in a magnetic field. Occasionally, the coercivity first seen is in the region of 10 oersteds, decreasing to 1 or 2 oersteds at a thickness of about 300 A., and thereafter remaining constant up to about 1,500 A. Very rarely the coercivity has been seen to increase slightly as the thickness increases from 150 to 1,500 A. On other substrata, the behaviour of the coercivity during deposition may be markedly different from the above. If the glass is coated with aluminium a few hundred angstroms thick, for example, which is then oxidized, an initial coercivity of 10–20 oersteds, steadily decreasing during deposition to a value of 1–5 oersteds at a thickness of about 1,500 A. has been found. This behaviour is more like that observed by Tiller and Clark.

The apparatus has also been used to monitor a small number of films electroplated on to a copper base. In these experiments a behaviour similar to that described for the evaporation on to aluminium oxide was obtained.

The use of an alternating aligning field which has a zero value twice in each cycle is perhaps questionable. As, for a similar set of conditions, nearly all specimens exhibit a distinct pattern of magnetic behaviour during deposition, it seems rather unlikely that the variations observed can be attributed to the

use of an alternating field. Certainly it is possible to produce magnetic specimens with a well-defined magnetic axis and a relaxation time of less than 200 millimicroseconds in an applied field of twice the coercive field.

These experiments show that the variation of the coercivity of thin films during formation is not a simple relation as given by Néel[1] but is influenced very strongly by secondary effects such as the nature of the substratum.

An apparatus similar to that described above has also been developed by K. E. Drangeid.

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Examination of Particulate Matter on Filter Membranes

Fine filter membranes with maximum pore sizes less than 1μ are now readily available for collecting solid material suspended in a liquid. As the membranes are of very uniform thickness, they may be examined under a microscope for the determination of the sizes and nature of the particles deposited on them. We have used a simple and effective technique for preparing slides incorporating the sample membrane. The essential feature of the method is that the membrane is made transparent to permit the use of transmitted light without disturbing the particle distribution.

A water ejector pump is usually used to assist filtration. By keeping this running the membrane may be dried in a few minutes. With the suction still applied, a fixative is poured down the side of the filter funnel so as to spread steadily across the membrane and be drawn through it. The forces acting on the particles are such that these are held against the membrane and are not disturbed by the advancing liquid front. The fixing process is complete when the fixative has been drawn through the membrane and the latter is again dry.

With the correct choice of fixative the membrane retains its porosity, and is thus capable of being rendered transparent by saturation in Canada balsam diluted with xylene. It can be mounted as desired without fear of disturbing the particles. We have used a solution of 0·5 per cent (w) 'Perspex' in chloroform as the fixative, and found it to be eminently suited to our application.

Where an automatic particle counter is used care must be taken to choose a membrane exhibiting negligible grain when treated, and to ensure that the drying processes are carried to completion, otherwise blotches caused by trapped air or liquid other than balsam may result in counting-errors.

We wish to thank the Directors of 'Shell' Research, Ltd., for permission to publish this communication.

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Refractivity and Lattice Constant Ratios of Lithium-6- and Lithium-7-rich Fluorides

The Industrial Group of the United Kingdom Atomic Energy Authority has provided small quantities of lithium compounds, containing different proportions of the isotopes lithium-6 and lithium-7, for use by its Research and Development Laboratories at Capenhurst.

Some of the material has been converted to lithium fluoride, and the refractivity of vacuum-grown crystals containing respectively (*A*) 90 per cent lithium-6, and (*B*) 95 per cent lithium-7, has been determined in the Natural Philosophy Department, Aberdeen, using a Hilger–Watts 'Research' pattern spectrometer, with 6·5 in. diameter glass circle. Prism *A* has faces 22 mm. × 26 mm., and prism *B*, 35 mm. × 26 mm. The observations were reduced to a uniform temperature of 21° C., and to standard atmospheric pressure.

Table 1. Variation of Refractive Index of Lithium Fluoride with Wave-length

λ (A.)	$n(A)$ (90 per cent lithium-6 fluoride)	$n(B)$ (95 per cent lithium-7 fluoride)	$n(N)$ (normal lithium fluoride)
4471·48	$1{\cdot}39618_{8(6)}$	$1{\cdot}39631_{3(4)}$	1·396310
5015·68	$1{\cdot}39414_{3(7)}$	$1{\cdot}39428_{6(4)}$	1·394289
5893·7	$1{\cdot}39189_{9(3)}$	$1{\cdot}39206_{8(7)}$	1·392066
6678·15	$1{\cdot}39049_{7(3)}$	$1{\cdot}39068_{8(3)}$	1·390683

Table 1 gives indices for four wave-lengths. Each value is the mean of three independent mean values, obtained from measurements on all three angles of the prism. The bracketed figures are the average residual errors ($\times 10^6$). The overall error was 5×10^{-6} for prism *A* and 4×10^{-6} for prism *B*. The last column, with values for the refractive index of normal lithium fluoride, is from measurements by Tilton and Plyler at the National Bureau of Standards[1].

Table 2. Variation with Wave-length of Refractive Index Differences

λ (A.)	$n(B) - n(A)$	$n(N) - n(A)$	$n(B) - n(N)$
4471·48	$12{\cdot}8 \times 10^{-5}$	$+ 12{\cdot}6 \times 10^{-5}$	$+ 0{\cdot}2 \times 10^{-5}$
5015·68	13·8	+ 14·1	− 0·3
5893·7	16·4	+ 16·8	− 0·4
6678·15	18·8	+ 18·6	+ 0·2

Table 2 shows the difference in refractivity between the enriched specimens *A* and *B*, and also between these and normal lithium fluoride. The major variation of 85 per cent in the proportion of lithium-7 from *A* to *B* produces an effect which varies from 13 to 19 $\times 10^{-5}$ in the range considered. Hence the difference of 2·4 per cent between *B* and normal lithium fluoride (92·6 lithium-7) should produce a shift of $n(B) - n(N)$ only ranging from 0·36 to $0{\cdot}53 \times 10^{-5}$ which is of the same order as the error. Moreover, Tilton and Plyler[1] found that there are small variations in the fifth decimal place between prisms of normal lithium fluoride, so that the close agreement shown in the last column between $n(B)$ and $n(N)$ is satisfactory.

The difference in refractivity increases with wave-length and can be fitted closely to an expression $x + y\lambda^2$. Using the least squares method, the values for $n(B) - n(A)$ are $x = 7{\cdot}723$, $y = 24{\cdot}83$ and for $n(B) - n(N)$, $x = 7{\cdot}870$, $y = 24{\cdot}60$. It is suggested

that the term x arises primarily from the change in lattice constant, and the variable term from the change in infra-red dispersion frequency with the isotopic fraction.

X-ray measurements by Thewlis[2] show that the lattice constant of lithium-6 fluoride exceeds that of lithium-7 fluoride by 2×10^{-4} parts. This dilation would produce a reduction in refractivity of the order of 20×10^{-5}, were it not partially offset by a rise in the sum of the ionic polarizabilities. However, the net effect of expansion at constant composition is effectively displayed by the temperature coefficient (dn/dT) of normal lithium fluoride, which is $-1{\cdot}65 \times 10^{-5}$ at a mean wave-length in the visible region.

The linear expansion coefficient of lithium fluoride at 20° C. is $3{\cdot}44 \times 10^{-5}$ per deg. C., so that a temperature rise ΔT of about 5 deg. C. produces the same dilation of the lattice in normal lithium fluoride as the change in composition from B to A at constant temperature. The product of the equivalent temperature rise and the temperature coefficient (dn/dT) gives a term of the order of -8×10^{-5}, which is close to the observed values of x. Conversely, x may be used to estimate the lattice dilation, and Table 3 shows the equivalent temperature rise ΔT, the expansion ratio (da/a), the change Δf in the isotopic fraction, and the expansion ratio $(da/a)_{100}$ scaled linearly to a 100 per cent change in isotopic fraction. The mean value is $1{\cdot}94 \times 10^{-4}$, in close agreement with the X-ray value (2×10^{-4}).

Table 3. Data for Derivation of $(da/a)_{100}$

Data	x	ΔT	(da/a)	Δf (per cent)	$(da/a)_{100}$
$n(B)-n(A)$	7·723	4·77	$1{\cdot}64 \times 10^{-4}$	85	$1{\cdot}93 \times 10^{-4}$
$n(B)-n(N)$	7·870	4·68	$1{\cdot}61 \times 10^{-4}$	82·6	$1{\cdot}90 \times 10^{-4}$

The equivalent rise of temperature simulates the effect of an increased amount of lithium-6 at sufficiently high frequencies, but in the visible region there will be a further difference arising from the increase in infra-red dispersion frequency. The refractivity at 23·6° C. of normal lithium fluoride, from 0·4 to 5·9μ, has been represented[1] by a Ketteler–Helmholtz dispersion formula:

$$n^2 = 1 - \frac{5{\cdot}1281966\lambda^2}{797{\cdot}8925296 - \lambda^2} + \frac{0{\cdot}92556295\lambda^2}{\lambda^2 - 0{\cdot}0053160}$$

The second term is of the form $-\dfrac{a\lambda^2}{\lambda^2_R - \lambda^2}$, where λ_R is the effective infra-red dispersion wave-length. Thus a change $d\lambda_R$ with variation in composition will produce a change in refractive index:

$$dn \simeq \frac{a\lambda^2}{n\lambda^2_R}\left(\frac{d\lambda_R}{\lambda_R}\right)$$

which is of the required form $y_c\lambda^2$. Infra-red transmission and reflectivity measurements on materials A and B accord with the assumption that the product $m\lambda_R^{-2}$ is constant[3], where m is the reduced mass, so that the ratio $(d\lambda_R/\lambda_R) = 0{\cdot}0485$ for B and N, giving a calculated value $y_c = 22{\cdot}4$, in substantial agreement with the observed value $y = 24{\cdot}6$. For the B and A observations, the corresponding values are $y_c = 23{\cdot}1$ and $y = 24{\cdot}8$.

Thus the differences in refractivity are in close agreement with those predicted from existing X-ray, dispersion and expansion observations. Fig. 1 shows the variation of $n(B) - n(A)$ with wave-length;

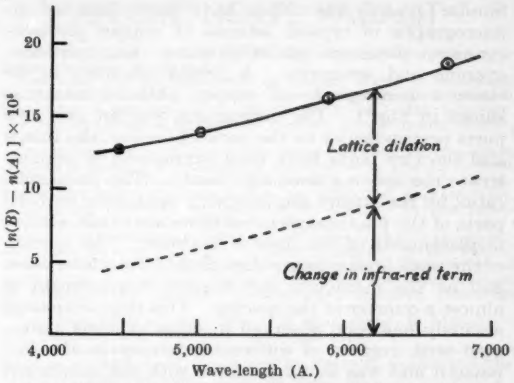

Fig. 1. Excess refractive index of lithium-7 fluoride-rich (B) over lithium-6 fluoride-rich (A) prism. The full curve is the theoretical excess for the observed lattice constant ratio $a(^6LiF)/a(^7LiF) = 1{\cdot}0002$ and for the increase of 5 per cent in the infra-red dispersion frequency from B to A. The dashed curve is the change arising from the infra-red term alone

the full curve gives the computed values for a dilation $(da/a)_{100} = 2 \times 10^{-4}$, and for a ratio $(d\lambda_R/\lambda_R) = 1{\cdot}05$ appropriate to an 85 per cent change in composition. The residuals are less than $0{\cdot}4 \times 10^{-5}$.

We thank the Ministry of Supply for a grant providing the crystal-growing facilities in the Natural Philosophy Department at Aberdeen, and the Chemical Services Department, Capenhurst Works, United Kingdom Atomic Energy Authority, for preparing and analysing the lithium fluoride.

We thank Mr. W. Mitchell for assistance in operating the furnace, and in preparation of the prism blanks, which were polished by Messrs. Barr and Stroud, Ltd., Glasgow.

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Spacing Anomaly in Electron Microscope Images of Crystal Lattices

Since Menter's observation[1] on electron microscope images of crystal lattices of metal phthalocyanines, several authors[2–7] have observed a variety of lattices in this way. Interpreting the image in terms of the kinematic theory of electron diffraction and Abbe's theory of image formation, Menter concluded that it should consist of parallel lines with equal spacing. He measured[2] the spacings of many images of platinum phthalocyanine and concluded that their average value does in fact coincide with the spacing of the lattice planes. Uyeda *et al.*[3] suggested that an image of the superlattice spacing of about 90 A. observed in antigorite crystals is useful for checking the magnification of electron micrographs because of its constancy.

In analysing some moiré patterns[8] one of us (H. H.) found local spacing anomalies in the image, where the Bragg reflecting condition was not exactly satisfied.

Similar spacing anomalies have been detected in micrographs of crystal lattices of copper phthalocyanine, platinum phthalocyanine, zinc phthalocyanine and antigorite. A typical anomaly in an electron micrograph of copper phthalocyanine is shown in Fig. 1. The micrograph was cut into two parts perpendicular to the parallel lines of the image and the two parts have been juxtaposed to demonstrate the spacing anomaly clearly. The lines indicated by the arrows coincide with each other on both parts of the photograph; but there are small relative displacements of the lines in between. The spacing of the weak lines is larger than that of the strong ones, and at the maximum the relative displacement is almost a quarter of the spacing. This type of spacing anomaly has been observed in other crystals associated with regions of different intensity in the line pattern and was found to move with the movement of the region of different intensity.

The anomaly may be explained by the dynamical theory of electron diffraction. When the angular setting of the crystal deviates slightly from the Bragg position, the wave vectors of the primary and reflected waves in the crystal change from those at the Bragg setting. Since the image is formed by the interference of primary and reflected waves, it may be expected that the image will vary with the deviation from the Bragg angle. Some calculations, reported in detail elsewhere, have been made on this basis where one Bragg reflexion only is excited, and these explain the anomaly satisfactorily.

The calculation shows that the lattice image of a plate-shaped crystal is composed of parallel lines, but the positions of the lines do not necessarily coincide with the positions of the potential maxima in the crystal, and, moreover, the contrast of the image changes both with the thickness of the crystal and the deviation from the Bragg angle. In a bent plate-shaped crystal the lattice image is formed only on the extinction contour. In the centre of the contour where the Bragg condition is satisfied exactly the spacing of the image is equal to that of the original lattice, but it deviates from this either by expansion or contraction near the edge where the Bragg condition is not exactly satisfied.

For example, if a crystal is bent into the form of a cylinder as shown in Fig. 2 and the thickness of the

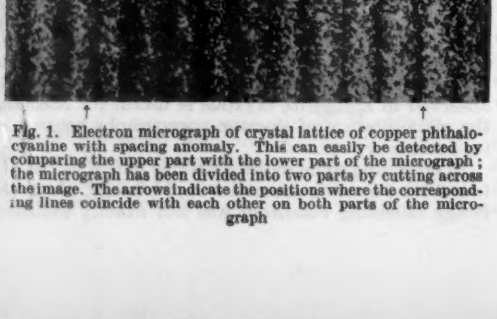

Fig. 1. Electron micrograph of crystal lattice of copper phthalocyanine with spacing anomaly. This can easily be detected by comparing the upper part with the lower part of the micrograph; the micrograph has been divided into two parts by cutting across the image. The arrows indicate the positions where the corresponding lines coincide with each other on both parts of the micrograph

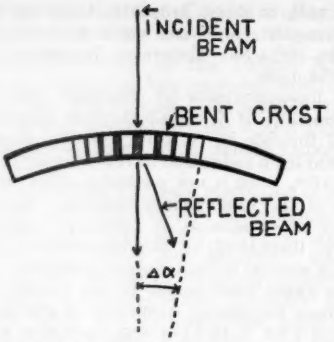

Fig. 2. Relation between the incident beam and uniformly bent crystal. $\Delta\alpha$ is an angle of bending

crystal is $t_0 = \lambda E/4V_g$ (where λ is wave-length, E is accelerating potential, V_g is the Fourier coefficient of the crystal potential, which is about 240 A. and 300 A. for the 201 plane of copper phthalocyanine and platinum phthalocyanine respectively), the image in the centre of the extinction contour has the true spacing of the crystal lattice and maximum contrast, whereas near the edge of the contour the spacing is increased and the contrast lowered. If the thickness is $2t_0$ the image does not appear along the centre of the extinction contour but only at the brim with increased spacing. If the thickness is $3t_0$ the contrast of the image at the centre is reversed compared with that at t_0, that is, the positions of the lines shift by one-half spacing.

The thickness and mode of bending of the crystal shown in Fig. 1 are not known exactly, but it is estimated that the former is several hundred angstroms and the local bending can easily be larger than that corresponding to the angle $\Delta\alpha = 8 \times 10^{-3}$ rad. necessary to shift the image by one-quarter spacing. The calculation given above is therefore probably applicable to the present observation. It should be noted that the spacing anomaly may occur sometimes both as a result of bending and as a result of thickness variation across the crystal. It is concluded that the anomaly is not due to any anomaly in the crystal lattice spacing but arises from the dynamical effects in scattering of electrons by crystals.

We wish to express our sincere thanks to Prof. K. Tanaka and Prof. R. Uyeda for useful discussions.

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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, April 6

BRITISH INSTITUTION OF RADIO ENGINEERS, COMPUTER GROUP (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 3 p.m. and 6 p.m.—Symposium on "Large Capacity Storage Devices".

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Discussion on "Co-operation between the Electricity and Gas Industries" opened by Mr. F. C. Smith, M.B.E.

SOCIETY OF ENGINEERS (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. George Constantinesco: "Sonics".

SOCIETY OF CHEMICAL INDUSTRY, LONDON SECTION (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Mr. W. A. M. Edwards: "Chemical Industry and the Free Trade Area".

RADAR AND ELECTRONICS ASSOCIATION (at the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2), at 7 p.m.—Dr. T. E. Allibone, F.R.S.: "Thermonuclear Research".

Monday, April 6—Wednesday, April 8

SOCIETY FOR GENERAL MICROBIOLOGY (in the Beveridge Hall, Senate House, University of London, W.C.1)—Twenty-eighth General Meeting.

Monday, April 6—Friday, April 10

FIFTH INTERNATIONAL INSTRUMENT SHOW (at 4 Tilney Street, Park Lane, London, W.1).

Tuesday, April 7

PHYSICAL SOCIETY, ACOUSTICS GROUP (joint meeting with the INSTITUTE OF PHYSICS, in the Physics Department, The University, Southampton)—All-day Symposium on "New Techniques in the Analysis of Noise and Vibration".

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENT AND CONTROL SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. M. E. Haine and Mr. J. Vine: "An Electron Trajectory Tracer for use with the Resistance Network Analogue".

SOCIETY OF CHEMICAL INDUSTRY, PLASTICS AND POLYMER GROUP (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Dr. J. Haslam and Mr. A. R. Jeffs: "Applications of Gas-Liquid Chromatography to the Work of a Plastics Analytical Department"; Mr. C. D. D'Oyly-Watkins, Mr. G. L. Palmer and Mr. C. M. Robertson: "Differential Thermal Analysis of some High Polymers".

Tuesday, April 7—Friday, April 17

FACTORY EQUIPMENT EXHIBITION (at Earls Court, London, S.W.5).*

Wednesday, April 8

CHEMICAL SOCIETY (in the Large Hall, Friends House, Euston Road, London, N.W.1), at 10.30 a.m.—Prof. H. J. Emeléus, F.R.S.: "Some Inorganic Polymers" (Presidential Address).

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. L. Berry and Mr. B. P. Ruxton: "The Structure and Form of Hong Kong Harbour"; Dr. W. S. Pitcher and Prof. H. H. Read: "The Aureole of the Main Donegal Granite".

INSTITUTION OF MECHANICAL ENGINEERS, INTERNAL COMBUSTION ENGINE GROUP (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Discussion on "What is the Present Position of the Gas Turbine Relative to the Diesel Engine for Satisfactory Stationery, Marine and Automobile Applications".

PHYSICAL SOCIETY (in the Main Lecture Theatre, The Physiology Laboratory, The University, Oxford), at 8.30 p.m.—Prof. H. S. W. Massey, F.R.S.: "Collisions" (43rd Guthrie Lecture).*

Thursday, April 9

ROYAL ANTHROPOLOGICAL INSTITUTE (at 21 Bedford Square, London, W.C.1), at 5.30 p.m.—Dr. Raymond Allchin: "The First Settlers in South India: Recent Research at Neolithic Sites in the Deccan".

INSTITUTE OF BIOLOGY, LONDON BRANCH (joint meeting with the CHELSEA COLLEGE OF SCIENCE AND TECHNOLOGY BIOLOGICAL AND GEOLOGICAL SOCIETIES, at the Chelsea College of Science and Technology, Manresa Road, London, S.W.3), at 7 p.m.—Meeting on "Modern Ideas of Continental Drift". Speakers: Dr. J. A. Clegg and Dr. A. J. Cain.

Friday, April 10

ROYAL ASTRONOMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Prof. A. A. Mikhailov: "The Deflection of Light by the Sun's Gravitational Field" (George Darwin Memorial Lecture).

MEDICAL RESEARCH COUNCIL (at the National Institute for Medical Research, Mill Hill, London, N.W.7), at 5 p.m.—Dr. S. E. Luria (Massachusetts Institute of Technology, Cambridge, Mass.): "Mechanisms of Infective Heredity in Bacteria".*

INSTITUTION OF MECHANICAL ENGINEERS (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Dr. W. B. Lewis: "Canadian Atomic Energy Development in Review and Prospect" (James Clayton Lecture).

RADAR AND ELECTRONICS ASSOCIATION (at Norwood Technical College, Knight's Hill, London, S.E.27), at 7 p.m.—Mr. D. C. Thomas: "A Modern British Marine Radar" (The B.T.H.601 "Escort").

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT PSYCHOLOGIST (with an honours degree or equivalent qualification in psychology, and preferably postgraduate research experience in experimental or clinical psychology)—The Secretary, The National Hospital for Nervous Diseases, Queen Square, London, W.C.1 (April 10).

PLANT BREEDER (with an honours degree in botany and experience in plant breeding or a postgraduate qualification in genetics or plant breeding) IN THE TEA RESEARCH INSTITUTE of Ceylon—Dr. F. R. Tubbs, East Malling Research Station, near Maidstone, Kent (April 10).

ASSISTANT LECTURER or LECTURER IN APPLIED MATHEMATICS—The Secretary, The University, Exeter (April 11).

ASSISTANT PHYSICIST (with an honours degree in physics and preferably some previous experience of hospital physics) IN THE RADIOTHERAPEUTIC CENTRE, for duties concerned with a wide variety of applications of physics to clinical radiotherapy and other branches of medicine—The Secretary, Addenbrooke's Hospital, Cambridge (April 11).

LECTURER (with a special interest in stratigraphy) IN GEOLOGY—The Secretary, The University, Edinburgh (April 11).

LECTURER (preferably with an interest in molecular weight measurement or nuclear magnetic resonance) IN PHYSICAL CHEMISTRY—The Secretary, The University, Aberdeen (April 15).

LECTURER (with a special knowledge of the strength of materials, or theory of machines, or applied thermodynamics) IN MECHANICAL ENGINEERING; and a Lecturer (with a special knowledge of applied aerodynamics and/or aircraft performance) IN AERONAUTICAL ENGINEERING—The Principal, Coventry Technical College, Butts, Coventry (April 16).

SENIOR LECTURERS, LECTURERS, and ASSISTANT LECTURERS (honours graduates, preferably with research experience) IN THE DEPARTMENT OF PHYSICS—The Clerk to the Governors, Chelsea College of Science and Technology, Manresa Road, London, S.W.3 (April 18).

ASSISTANT LECTURER IN PHYSICS—The Registrar, University College of North Staffordshire, Keele, Staffs (April 20).

LECTURER IN ARCHÆOLOGY—The Secretary, The Queen's University, Belfast (April 20).

SUPERINTENDENT OF LABORATORIES IN THE DEPARTMENT OF CHEMISTRY—The Registrar, University College, Singleton Park, Swansea (April 20).

FELLOW (honours graduate in some branch of chemistry, with some postgraduate research experience) IN PROTEIN CHEMISTRY in the Division of Protein Chemistry, C.S.I.R.O., Parkville (near the University of Melbourne), to apply ultra-violet and visible spectrophotometry in studies of the chemistry of extracted wool proteins and related model compounds and to relate the findings to similar measurements on the intact fibre—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 463/116 (April 25).

LECTURER IN INORGANIC CHEMISTRY—The Registrar, University College of Wales, Aberystwyth (April 25).

LECTURER IN THE DEPARTMENT OF MATHEMATICS, University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, April 25).

LECTURER (with qualifications in either chemistry or physics or glass technology) IN THE DEPARTMENT OF GLASS TECHNOLOGY—The Registrar, The University, Sheffield (April 25).

LECTURER (with special qualifications in fluid dynamics) IN MATHEMATICS—The Secretary of Faculties, University Registry, Oxford (April 25).

LECTURER IN PHILOSOPHY—The Secretary, Balliol College, Oxford (April 30).

RESEARCH FELLOW (with a Ph.D. degree or equivalent research experience in physical-organic chemistry or biochemistry) IN THE CHEMISTRY DEPARTMENT, for an investigation of the mode of action of germicides—The Professor of Chemistry, The University, Hull (April 30).

SCIENTIFIC OFFICER (with a good honours degree, preferably with postgraduate experience) IN THE PLANT PATHOLOGY DEPARTMENT, to work on virus diseases of field crops—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (April 30).

ASSISTANT LECTURER (interested in plant physiology or the genetics of micro-organisms) IN BOTANY; and an ASSISTANT LECTURER IN PSYCHOLOGY—The Registrar, The University, Hull (May 1).

DIRECTOR OF THE INSTITUTE OF STATISTICS—The Registrar, University Registry, Oxford (May 2).

LECTURER (with good academic qualifications and experience in one of the following fields: electrical power engineering, electrical engineering materials, or electrical engineering physics) IN THE DEPARTMENT OF ELECTRICAL ENGINEERING—The Registrar, The University, Leeds 2 (May 2).

READER IN MECHANICAL ENGINEERING at Imperial College—The Academic Registrar, University of London, Senate House, London, W.C.1 (May 6).

LECTURER IN PURE MATHEMATICS—The Secretary, The Queen's University, Belfast (May 8).

CHAIR OF PHYSICS—The Registrar, University College of North Staffordshire, Keele, Staffs (May 9).

UNIVERSITY STUDENTS or FELLOWS, for experimental or theoretical research in nuclear and elementary particle physics—The Professor of Natural Philosophy, The University, Glasgow, W.2 (May 9).

CHAIR OF EDUCATION at University College, Ibadan, Nigeria—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (May 10).

LECTURER IN PHYSICS; and LECTURERS (2) IN ANATOMY—Joint Clerk to the University Court, Queen's College (University of St. Andrews), Dundee (May 16).

LECTURER (preferably with an interest in histology and biochemistry) IN PHYSIOLOGY—The Secretary of University Court, The University, Glasgow (May 16).

ASSISTANTS (either sex, with a good reading knowledge of Russian or Italian, and preferably with scientific interests), for abstracting papers in economic entomology—The Director, Commonwealth Institute of Entomology, 56 Queen's Gate, London, S.W.7.

CHIEF PLANT PROTECTION OFFICER (with a degree in entomology and considerable experience in economic entomology and plant quarantine services) in the Ministry of Agriculture and Lands, Jamaica, to direct and supervise the Plant Protection Division (including Entomology and Plant Pathology Sections), and to maintain an effective plant quarantine service—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/32/023.

LABORATORY TECHNOLOGIST (PLANT PATHOLOGIST) (with a university degree with botany as the main subject) IN THE DEPARTMENT OF AGRICULTURE, Kenya, to assist with laboratory research and field experiments in problems of coffee pathology and physiology—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/7/046.

LECTURER (with research and teaching experience) IN PLANT PHYSIOLOGY—The Professor of Plant Physiology, Imperial College of Science and Technology, Prince Consort Road, London, S.W.7.

MASTER (graduate) TO TEACH MATHEMATICS, PURE AND APPLIED, up to Advanced Level—The Director of Studies, The Nautical College, Pangbourne, Berkshire.

READER (with a good degree of a British university, research qualifications in some branch of applied mathematics or statistics, and preferably experience of teaching in a university or major technical college) IN APPLIED MATHEMATICS—The Clerk to the Governing Body, Battersea College of Technology, London, S.W.11.

READERS, SENIOR LECTURERS and LECTURERS IN CHEMISTRY, ELECTRICAL ENGINEERING, CIVIL ENGINEERING, MECHANICAL ENGINEERING and PHYSICS; and SENIOR LECTURERS and LECTURERS IN CHEMICAL ENGINEERING, METALLURGY, PHARMACEUTICAL CHEMISTRY, PHARMACEUTICS, PHARMACOLOGY, MATHEMATICS, STATISTICS and ZOOLOGY—The Registrar, Bradford Institute of Technology, Bradford 7.

SOIL SURVEYOR (with a university degree, preferably with honours, in agricultural chemistry or pure chemistry, or, alternatively a degree in geology or geography, and a good knowledge of chemistry) in British Guiana, for soil surveys on the coastlands and the underdeveloped interior—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/30/017.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Government of Northern Ireland: Ministry of Agriculture. Leaflet No. 13: Contagious Abortion and Infectious Sterility of Cattle. Pp. 8. (Belfast: Ministry of Agriculture, 1958.) [102

Northampton College of Advanced Technology. Prizes and Certificates, Session 1957–1958. Pp. 26. (London: Northampton College of Advanced Technology, 1959.) [102

The Registrar General's Statistical Review of England and Wales for the year 1957. Part 2: Tables, Civil. Pp. xii+200. (London: H.M. Stationery Office, 1959.) 11*s.* 6*d.* net. [102

University of Hull. Annual Report, 1957–58. Pp. 67. (Hull: The University, 1959.) [102

On Being a Technologist. By Prof. D. G. Christopherson. (Technics and Purpose, No. 5.) Pp. 33. 2*s.* 6*d.* net. The Educated Man Today and Tomorrow. By Sir John Wolfenden. (Technics and Purpose, No. 6.) Pp. 25. 2*s.* 6*d.* net. (London: SCM Press, Ltd., 1959.) [102

Ministry of Labour and National Service. Studies in Official Statistics No. 4: The Length of Working Life of Males in Great Britain. Pp. 24. (London: H.M. Stationery Office, 1959.) 3*s.* 6*d.* net. [102

The Civic Trust. Your Town: an Outline of the Work of an Amenity Society. Pp. 20. 1*s.* The Civic Trust. (A paper on the first year's work presented by Sir Howard Robertson, a Trustee of the Civic Trust, to the 58th National Conference of the National Housing and Town Planning Council, Brighton, 22nd October, 1958.) Pp. 7. (London: The Civic Trust, 79 Buckingham Palace Road, 1959.) [112

Institute of Personnel Management. Occasional Papers, No. 13: Personnel Management in Perspective: Suggestions on the Correct Place of Personnel Activities in Business Organization. By L. Urwick. Pp. 23. (London: Institute of Personnel Management, 1959.) 4*s.* [112

National Society for Clean Air. Proceedings of the 25th Annual Conference, Llandudno, 1st to 3rd October, 1958. Pp. 111. (London: National Society for Clean Air, 1959.) 12*s.* 6*d.* [112

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Air Ministry: Meteorological Office. Geophysical Memoirs No. 100: World Distribution of Atmospheric Water Vapour Pressure. By G. A. Tunnell. Pp. i+61. (M.O. 584h.) 10*s.* net. Professional Notes, No. 126: A Synoptic Study of Anomalies of Surface Air Temperature over the Atlantic Half of the Northern Hemisphere. By J. M. Craddock and C. A. S. Lowndes. Pp. 6+11 figures. (M.O. 623f.) 3*s.* net. (London: H.M. Stationery Office, 1958.) [112

Other Countries

United States Department of the Interior: Geological Survey. Bulletin 1000-H: Geochemical Prospecting Studies in the Bullwhacker Mine Area, Eureka District, Nevada. By Alfred T. Miesch and Thomas B. Nolan. Pp. iii+397–408. 15 cents. Bulletin 1042-F: Geology and Coal Resources of the Tiptop Quadrangle, Kentucky. By Stewart W. Welch. Pp. iv+585–612+plates 50–55. n.p. Bulletin 1042-R: Geology of the Ord Mine, Mazatzal Mountains, Quicksilver District, Arizona. By John N. Faick. Pp. iii+685–698+plates 58–60. 1 dollar. Bulletin 1046-J: Geologic Features of Areas of Abnormal Radioactivity South of Ocala, Marion County, Florida. By Gilbert H. Espenshade. Pp. iii+205–219+plates 12–15. 1 dollar. Bulletin 1053: Geology and Coal Resources of the Centralia-Chehalis District, Washington. By Parke D. Snavely, Jr., R. D. Brown, Jr., and Albert H. Roberts. With a Section on Microscopical Character of Centralia-Chehalis Coal by J. M. Schopf. Pp. vi+159+13 plates. n.p. Bulletin 1059-F: Selected Annotated Bibliography of the Geology and Occurrence of Uranium-Bearing Marine Black Shales in the United States. By Carolyn E. Fix. Pp. iii+263–325+plate 3. 25 cents. Bulletin 1061-D: Quaternary Geology of Boulder Mountain, Aquarius Plateau, Utah. By Richard F. Flint and Charles S. Denny. Pp. iv+103–164+plates 6–8. 1 dollar. Bulletin 1070-B: Lead-Alpha Ages of the Mesozoic Batholiths of Western North America. By Esper S. Larsen, Jr., David Gottfried, Howard W. Jaffe and Claude L. Waring. Pp. iv+35–62. 15 cents. (Washington, D.C.: Government Printing Office, 1958.) [281

Die Fehler in der Relativitäts-Theorie und ihre Lösung die Massenveränderlichkeit, ein Trugschluss? Von Ludwig Brösske. Pp. 20. (Düsseldorf-Benrath: Astronomische Vereinigung, 1959.) [291

Transactions of the Bose Research Institute, Calcutta. Vol. 22, No. 8: Recent Work on Termite Research in India (1947–57). By Dr. M. L. Roonwal. Pp. 77–100+1 plates. (Calcutta: Bose Research Institute, 1958.) [301

Recent Researches on Population Dynamics and Evolutionary Problems in the Desert Locust, together with a New Theory of the Visual Maintenance of Gregarization in Locusts. By Dr. M. L. Roonwal. (Reprinted from the *Journal of the Zoological Society of India*, Vol. 9, No. 1, June 1957.) Pp. 72–96+1 plate. (The Tata Medal Lecture.) (Calcutta: Zoological Society of India, 1958.) [301

Western Australia: Department of Mines. Mineral Resources of Western Australia. Bulletin No. 6: The Gypsum Deposits of Western Australia. By L. E. de la Hunty and H. G. Low. Pp. 110+6 plates and 2 figures. (Perth: Government Printer, 1958.) [301

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Smithsonian Institution. Report of the Secretary and Financial Report of the Executive Committee of the Board of Regents for the year ended June 30, 1958. Pp. x+232+14 plates. (Smithsonian Publication 4345.) (Washington, D.C.: Government Printing Office, 1958.) [102

Economic Notes of the Chamber of Foreign Trade of the German Democratic Republic. No. 1 (January, 1959). Pp. 4. (Berlin: Chamber of Foreign Trade of the German Democratic Republic, 1959.) [102

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Peabody Museum of Natural History, Yale University. Bulletin 12: Natural History of the Marine Sponges of Southern New England. By Willard D. Hartman. Pp. xi+155+11 plates. Bulletin 13: Notes on a Collection of Birds from Mindoro Island, Philippines. By S. Dillon Ripley and D. S. Rabor. Pp. iv+82. (New Haven, Conn.: Peabody Museum of Natural History, Yale University, 1958.) [102

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Carnegie Institution of Washington. Year Book No. 57, July 1, 1957—June 30, 1958. Pp. xi+497+12 plates. (Washington, D.C.: Carnegie Institution, 1958.) 1 dollar, paper bound; 1.50 dollars, cloth bound. [102

Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

Annual subscription £7/15/–, payable in advance, postage paid to any part of the world

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